ANNUAL SCIENTIFIC REPORT

1975-76

TEA RESEARCH ASSOCIATION, CALCUTTA

OUR COVER

Growing tea plants in sand culture (inert media) in the Glass House under controlled conditions at Tocklai

TEA RESEARCH ASSOCIATION

Annual Scientific Report

The Tocklai Experimental Station of the Tea Research Association has pleasure in presenting the Annual Scientific Report (Part II) for the period 1st April, 1975 to 31st March, 1976. The Annual Administrative Report (Part I) of the Association for the same period is being issued separately from T.R.A., Calcutta.

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Director's Report

(1st April 1975 to 31st March 1976)

ORGANISATION

On the 31st March 1976, the Senior Staff consisted of :—

Directorate :

Director
N. K. Jain, M.Sc, Ag. (B.H.U.), Ph.D. (Illinois)

Deputy Director
D. N. Barbora, B.Sc. Mining (B.H.U.), M.Sc., Eng. (London), D.I.C., M.I.Ag.E.

Administration :

Administrative Officer
K. R. Gopalan

Asst. Administrative Officer
B. S. Kotoky, B.A., L.L.B.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal.) A.C.A.

Maintenance :

G. B. Singh, A.M.I.S.E.

Medical :

Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library and Publications Department :

Librarian & Asst. Publication and Information Officer
J. N. Sharma, M.A. (Gau.)

Soils & Meteorology Department :

Soil Scientist
S. K. Dey, B.Sc. (Cal.) Assoc. I.A.R.I.

Asst. Soil Scientist
N. G. Bhattacharjee, B.Sc. (Cal.)

Botany Department :

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D. (Gau.)

Asst. Plant Physiologists
B. N. Gogoi, B.Sc. (Gau.)
L. Manivel, M.Sc. Ag. (Madras), Ph.D. (California)

Agriculture Department :

Agronomist
F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist
B. C. Phukan, B.Sc. Ag. (Gau.) A.I.F.C.

Second Agronomist (Weed Control)
V. S. Rao, M.Sc. Ag. (Osmania), Ph.D. (Cornell)

Manager, Borbhetta Experimental Estate
H. N. Sharma, B.Sc. (Cal.)

Entomology Department :

Entomologist
B. Banerjee, M.Sc. (Cal.), M. S. (South Illinois), Ph.D. (London), F.A.Z., F.R.E.S. (London)

Asst. Entomologist
N. S. Sengupta, B.Sc. Ag. (Dac.)

Mycology Department :

Mycologist
G. Satyanarayan, B.Sc. (Hons) (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.

Biochemistry Department :

In-Charge, Biochemist
S. Chakraborty, M.Sc. Ph.D. (Cal.)

Tea Tasting Depatment :

Tocklai :

Second Tea Taster
A. K. Das, B.A. (Gau.)

West Bengal :

Tea Taster
R. P. Basu

Engineering Research & Development Department :
Senior Research Engineer
D. N. Barbora, B.Sc. Mining (B.H.U), M.Sc. Eng. (London), D.I.C., M.I.Ag. E.

Second Research Engineer
T. C. Baruah, B.Sc. (Hons) (Gau.), B.Sc. Mech. Eng. (BHU), M.Sc. Mech. Eng. (Manchester)

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau.)

Agricultural Economics Department :
Agricultural Economist
R. C. Awasthi, M.Com., LL.B., Ph.D. (Agra)

Advisory Department :
Senior Advisory Officer
P. C. Sharma, M.Sc. (BHU), Ph.D. (London), F.L.S.

Advisory Officer
T. K. Ghosh, B.Sc. (Patna), Assoc. I.A.R.I. Ph.D (Cornell)

UpperAssam :
Advisory Officer
J. Chakravartee, M.Sc. Ag. (Gau.)

Lower Assam :
Advisory Officer,
B. Borthakur, M.Sc. Ag. (Gau.)

Asst. Advisory Officer
S. C. Dey

North Bank :
Advisory Officer
H. Mitra, B.Sc. (Cal.)

Asst. Advisory Officer
M. Farook, B.Sc.Ag. (T.N.A.U.)

Cachar :
Advisory Officer
S. K. Sarkar, B.Sc. (Cal.), B.Sc. Ag. (BHU)

West Bengal :
Advisory Officer
S. Basu, B.Sc.Ag. (Hons.) (Delhi), Assoc. I.A.R.I.

Dooars & Terai :
Advisory Officer
B. C. Barbora, M.Sc. Ag. (I.A.R.I.)

Asst. Advisory Officer
K. N. Dutta

Darjeeling :
Advisory Officer
R. Padmanaban, B.Sc.Ag. (Madras)

SENIOR STAFF MATTERS

Appointment

The following appointments and promotions w made :

1.	Mr. N. S. Sengupta	promoted as Asst. Entom gist on 1st. April '75.
2.	Mr. A. K. Sengupta	promoted as Asst. Soil Sc tist on 1st April '75.
3.	Mr. N. C. Bhatta-charyya	promoted as Asst. Soil entist on 1st April '75.
4.	Mr. B. N. Gogoi	promoted as Asst. Plant P siologist on 1st April '75.
5.	Mr. J. N. Sharma	promoted as Librarian Asst. Publication & Infor tion Officer on 1st April
6.	Mr. P. K. Lala	promoted as Asst. Accou Officer on 1st April '75.
7.	Mr. K. R. Gopalan	appointed as Administrat Officer with effect from 1.7.
8.	Mr. R. Padmanaban	appointed as Advisory Off with effect from 23.8.75.
9.	Dr. V. S. Rao	appointed as Second Agro mist (Weed Control) wit effect from 24.10.75.
10.	Dr. L. Manivel	appointed as Assistant Pl Physiologist with effect fr 31st January, 1976.

Retirement

Mr. D. N Borbora, Senior Research Engineer & I puty Director retired from Association's service on 3 March, 1976.

Resignation

Mr. K. S. Gill, Administrative Officer resigned wi effect from 6th July, 1975.

Dr. K.L. Bajaj, Biochemist resigned on 2nd November, 1975.

Mr. S. Sen, Second Tea Taster of West Bengal Advisory Department resigned with effect from 18th Nov.'75.

TRAINEES

Mr. B. Ramessur from Mauritius completed four months training in tea culture.

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Three Research Students who were under the C.S.I.R. Junior Research fellowship scheme, worked at Tocklai during the year under review. They were attached to Botany, Mycology and Soils departments respectively.

LECTURE COURSES

The following lecture courses were held during the year : –

Surveying and Drainage Course for Planters

1st Course from 5th January, 1976
to
9th January, 1976

2nd Course from 19th January, 1976
to
23rd January, 1976

3rd Course from 27th January, 1976
to
31st January, 1976

VISITS

The Director attended the meetings of TRA's Executive Committee, AGM and Council of Management, Pesticide & Economic Advisory Committees; Agricultural and Engineering Sub-Committees; Evaluation Committee; Research Liaison and Development Committees of Tea Board at Calcutta and visited Delhi to attend IPIRI meetings; Biological Research Committee of C.S.I.R. ; ICAR/CSIR Interface Committee Meeting; CSIR Directors' Conference at Bangalore. He also visited Tamilnadu Agricultural University, Madras, Coonoor for UPASI Meeting, Jute Research Institute, Barrackpore, CDRI & ITRC at Lucknow.

Dr. F. Rahman visited Delhi to attend Agronomy Panel Meeting of ICAR and Calcutta for Agricultural Sub-committee & Agric. Chem. Adv. Committee Meetings. He also visited Coonoor, to attend UPASI Annual Conference in Sept. '75 and visited T.R.I. Sri Lanka.

Dr. G. Satyanarayana visited New Delhi on 12th April, 1975 for 2nd FAO & IUFRO World technical consultation on forest pests & diseases and, Calcutta on 19th August, 1975 to attend Agri-Chem. Advisory Sub-Committee meeting. He also visited Tamil Nadu Agricultural University to see the microbiology department from 20th to 27th August, 1975.

Dr. T. K. Ghosh attended UPASI Annual Conference in September, 1975. and visited T.R.I. Sri Lanka.

Dr. B. Banerjee attended CFRTI seminar on pesticides on 3rd to 8th February, 1976.

Mr. A. K. Biswas visited Computer Centre, Indian Institute of Technology, Madras in April, 1975 to discuss some of the computer problems and make arrangements for utilising their computer.

Dr. R. C. Awasthi and Mr. N. S. Venkatakrishnan visited Gauhati on 22nd and 23rd November, 1975 to attend a seminar "Problems & Prospects of Tea Industry in N. E. India" organised by N. E. India State Council. They also visited Dibrugarh to attend a seminar on "Economic Progress & Development of Modern Assam (1826-1947)", organised by Dibrugarh University on 23rd and 24th March, 1976.

Dr. V. S. Rao visited Jute Agricultural Research Institute, Barrackpore, G. B. Pant University of Agriculture and Technology, Pantnagar and Indian Agricultural Research Institute, New Delhi between January 1 and 11, 1976 to study the radiotracer and weed research programmes there.

Mr. A. K. Das visited Calcutta on 3rd February, 1976 to attend seminar on Bulk Packaging of tea for export.

VISITORS

The following distinguished persons visited Tocklai during the year under review :–

G. A. Whitaker, Chairman of Singlo Tea Co. Ltd., London.

D. J. K. Wadham of Singlo Tea Co. Ltd., London.
General J. N. Choudhury, Chairman of Andrew Yule & Co. Ltd., Calcutta.

His Excellency L. P. Singh, Governor of Assam.
Mr. B. Sivaraman, Member of Planning Commission, New Delhi.

Mr. P. C. Barua, Chairman, Training Committee, Assam Productivity Council, Digboi.
Mr. R. H. Tomson, University of Aberdeen, Scotland.
Mr. S. K. Dutta, Mg. Director of Assam Tea Corporation, Gauhati.

Mr. V. Raghuraman, National Productivity Council, New Delhi.

Mr. K. A. Zaman, ISGEC John Thompson, Calcutta.
Mr. S. K. Suri, Dy. Director, National Physical Laboratory, New Delhi.

Dr. J. H. Agarwal, Director, Instrumentation, J. N. Agricultural University, Jabalpur.
Mr. N. D. Joshi of Wanson (India) Pvt. Ltd., oona.P
Mr. P. M. Kulkarni of Wanson (India) Pvt. Ltd., Poona.
Mr. S. N. Majoomder of Heatly & Gresham Pvt. Ltd., Calcutta.

Mr. R. C. Punshi of Duncan Brothers, Calcutta.
Mr. S. L. Kessan of GK Tea Industrial Corporation, Calcutta.

Mr. S. K. Basu of the Directorate General of Technical Development, New Delhi.
Mr. J. Singh of Assam Agricultural University, Jorhat.
Mr. B. B. Bhagat of Voltas Ltd., Calcutta.
Mr. M. P. Prabhu of Steelworth Pvt. Ltd., Tinsukia.
Mr. V. P. Gupta of Samuel Osborn (India) Ltd., Calcutta

Mr. M. M. Tikari of Samuel Osborn (India) Ltd., Calcutta.

Mr. H. Svensson of SF Industries Ltd., Calcutta.
Mr. V. K. Sardana of Teema Consortium, Calcutta.
Mr. S. B. Sarkar, Dy. Chief Engineer, Coal Mines Authority, Calcutta.

Mr. V. Dudeja of J. Thomas & Co. (P) Ltd., Calcutta.
Mr. R. D. Tikmany of Mectea (India), Calcutta.
Mr. J. K. Borooah & Mr. G. L. Barua of Assam Tea Brokers Pvt. Ltd. Gauhati.

Mr. N. Rajasekharan of Pennwalt India Ltd., Bombay.
Mr. D. S. Jamwall of Octavius Steel & Co., Calcutta.
Mr. U. Ganguli of Wesman Eng. Co. (P) Ltd., Calcutta.
Mr. C. D. Rozario of C. R. Wallace Co. (P) Ltd., Calcutta.

Mr. C. M. Ho of C. M. Ho & Co., Makum Junc Assam.

Mr. M. Sen & Mr. S. N. Roy of Tea Consultanc Plantation Services, Calcutta.

Mr. H. P. Barooah of Barooah & Associates, Jorha
Mr. H. N. Bhuyan & Om Prakesh of Steelsworth (P) L
Mr. S. Mukherjee & Mr. A. Sen of Hoogly Doc & Eng., Co., Calcutta.

Mr. R.K. Saha of Mahindra & Mahindra Ltd., Calc
Mr. R. N. Bhargava, Scientist of C.S.I.R., New Delh
Mr. C. Kempanna, Asst. Director General of IC New Delhi.

Mr. B. L. Hansaria, District Judge of Jorhat.
Mr. Abdullah A. Ibrahim of Iraq.
His Excellency G. Nadal, Ambassador of Spain in Inc New Delhi.

Mr. M. Copillo of Agricultural & Industrial Corpc tion, New York.
Mr. Y. Nayudamma, Director General of CSIR, N Delhi.

Mr. R. Lal, Dean, College of Agricultural-Engineer & Technology, Bhubaneswar.
Mr. P. Sanyal, Director, Jute Development Corpo tion, Calcutta.
Mr. J. Bain, of James Finlay, Glasgow.
Mr. L. P. P. Maroussem & Mr. J. V. Henry Guimbe of Mauritius.
Mr. Pravat Misra of Ananda Bazar Patrika, Calcut
Mr. Gojen Tanti, Minister of Labour, Food & Co-oper tion, Govt of Assam.

Mr. S. K. Anand, Marketing Manager, Marketing Pv Ltd., Calcutta.
Mr. Lincoln Perera of Sri Lanka.
Mr. S. K. Kar of Toshniwals, Calcutta.
Dr. S. P. Popli, Central Drug Research Institute, Luc now.
Dr. M. S. Chadha, Bhabha Atomic Research Centr Bombay.

Mr. K. L. Luthra, Chief Mining Engineer, Dehradu
Dr. Asghar Hussain, R.R.L. Hyderabad.
Mr. M. Lamond, Chairman, L.S.C., London.
Mr. I. A. Ansari & Mr. A. A. Khan of Malayalam Plantation Ltd., Kerala.
Dr. Vinod Prakash, Economist, World Bank, Washing ton D.C., U.S.A.

Mr. K. G. Krishnamurthi, Chief of Administratior C.S.I.R., New Delhi.

Mr. F. R. Wilson, Director of Duncan Machneill & Co London.

Mr. O. D. Agnihotri, Chief Commercial Supdt., N.F. Railway, Gauhati.

Mr. & Mrs. Nair of Mudis, South India.

Mr. P. S. Hariharan, Chief (Finance) C.S.I.R., New Delhi.

Mr. V. S. Vyas, Sr. Professor of Indian Institute of Management, Ahmedabad.

Miss F. K. Wadia, Director, North Eastern Council Secrt., Shillong.

Mr. Som Raj Urs & Mr. R. K. Gupta of Munnar, Kerala.

Dr. G. Thyagarajan, Director, R.R.L. Jorhat.

Dr. A. S. Indulkar, BASF India Ltd., Bombay.

Mr. J. Alon of Isreal.

Mr. A. L. Taylor, Regional General Manager, IBM, New Delhi.

Mr. A. J. Young with six members Irish delegation.

Academician Mukhamedjanov, USSR, Tashkant & P. Sorokin, Vice Consellor for Agricultural affairs U.S.S.R. Embassy in New Delhi.

Dr. P. S. Bhatnagar, Joint Commissioner Govt. of India, Ministry of Agriculture, New Delhi.

Dr. J. P. Nauriyal, Director (Hort.) Govt. of India, Ministry of Agriculture, New Delhi.

Mr. P. Swaminathan, Advisory Officer, UPASI, Munnar.

Mr. P. L. Dutta, Visiting Agent, Duncan Brothers & Co., Calcutta.

Dr. S. Kulasegaram, Plant Physiologist, TRI Ceylon.

Mr. G. A. Cruickshank of Duncan Brothers & Co., Calcutta.

Dr. P. S. Rattan, Mycologist, Tea Research Foundation of Central Africa, Malawi.

Dr. P. Nandi of IDL Agro-Chemicals Ltd., New Delhi.

Mr. A. K. Tiwari, Octavius Steel & Co., Ltd., Calcutta.

Mr. R. N. Deogun, Visiting Agent & Mr. J. Bain of James Finlay & Co., Ltd., Calcutta.

Mr. Chandra Kant, Tea Export Adviser, Govt. of Mauritius.

Dr. T. D. Mukherjea of Voltas Ltd., New Delhi.

Dr. P. C. Bora, Prof. & Head, Dept. of Tea Husbandry & Technology, Assam Agricultural University, Jorhat.

Mr. J. D. Mittal of S.A.O., CSIR, New Delhi.

Prof. T. S. Sadasivan, Adviser to the C.S.I.R.

Dr. S. K. Mukherjee, Member, National Commission on Agriculture, New Delhi.

Dr. C. K. Atal, Director, R.R.L. Jammu.

Dr. H. K. Jain, Head Genetics Division, IARI, New Delhi.

Dr. I. S. Bhatia, Sr. Professor & Head of the Dept. of Biochemistry, Punjab Agricultural University, Ludhiana.

Mr. Angus Macnaghtan of Wallace Brothers, London.

Mr. Mrinal Baruah of Statesman, Shillong.

Mr. & Mrs. Donald L. S. Coombe of British High Commission, Calcutta.

Mr. David Little of Warren Plantation Services Ltd., London.

Mr. T. S. Broca, Chairman, Tea Board, Calcutta.

Dr. Rajendra Kumar, Director Economics, Reserve Bank of India, Calcutta.

Mr. Gatherne Whiteside of San Francisco, California, U.S.A.

Mr. S. P. Verma of I.C.A.R., Research Complex, Imphal.

Mr. P. N. Gupta, I.C.A.R., Tripura.

Mr. A. C. Arora, Dy. Director, Agricultural Centre, Arunachal Pradesh, Shillong.

Dr. R. K. Hazari, Dy. Governor, Reserve Bank of India, Bombay.

Mr. H. Ferguson of James Finlay & Co. Ltd., Glasgow, Scotland.

Mr. R. Wilson of Bacofoil Ltd. London.

Mr. Shyam Singh, I.C.A.R., Shillong.

General

Mr. R. Padmanaban joined this Department and took over charge of the Darjeeling Advisory Branch during the last week of December. Mr. S. K. Sarkar on being relieved from Darjeeling, took over the duties of Advisory Officer, Cachar, from Mr. J. Chakravartee who, in turn, opened the new Advisory Branch in Upper Assam. Mr. K. N. Dutta, Assistant Advisory Officer, who joined the West Bengal Advisory Branch in January, 1975, returned to Tocklai by the middle of December the same year.

Visits

The increase in the number of visits paid by the sory Officers during 1975-76, compared to the pr year, was mainly due to increase in the number of ber Estates in all areas as well as continued dema visits, particularly from the new members who h be nourished more than the experienced members

Table 1 gives the details of the advisory visits pa each district including the review of enrolment d the year under report.

Table 1. Details of advisory visits paid in the Member Estates during 1974-75 and 1975-76

District	No. of visits paid		No. of Member Estates visited during		Total number of Member Estates During	
	1974-75	1975-76	1974-75	1975-76	1974-75	1975-76
South Bank	287	418	226	295	283	303
North Bank	157	338	77	94	90	100
Cachar	112	106	52	56	56	64
Dooars	196	318	81	93	95	103
Terai	28	42	18	22	22	23
Darjeeling (including Sikkim)	125	125	53	59	55	59
Total	905	1347	507	619	601	652

Crop and Weather

The early cropping season of 1975-76 received a set-back in Nowgong, Golaghat and Jorhat sub-areas in particular because of the droughty conditions that prevailed during those months. Other areas had a fairly good weather and continued to harvest reasonable crop. The early set-back in the three sub-areas mentioned above, could not ultimately be made up, resulting in a comparatively lower total crop. The backend crop in Upper Assam, was, however, not as good compared to the previous years.

North Bank as a whole experienced more or less the similar weather conditions and the crop was also comparatively low as that of Nowgong, Golaghat and Jorhat sub-areas of the South Bank. Even though sufficient rain was received after the droughty spell, backend crop could not make good for the loss of the early crop sustained by North-Bank estates. The advantage of early precipitation during 1976 could not be fully utilised by the North Bank estates because the spring drought that followed, caused considerable damage to the unpruned and light skiffed teas particularly, in sandy areas.

Cachar experienced the same fate as North Bank duri the early season of 1975-76 with the estates in Hap Valley sub-area being the worst affected. Added this unfavourable weather condition, the first shower rain which was accompanied by hail storm was mo disastrous. Inspite of these unfavourable conditio a few estates who had adopted a balanced pruning cycl followed a high order of field management practic and were situated in comparatively favourable conditio ended up at par with 1974 figures.

As a result of the prolonged drought in early 197 most of the estates in the Dooars, Terai and Darjeelin lost crop quite heavily. Inspite of good harvest in th rains and backend period, this deficit could not be mad up. Darjeeling estates, however, harvested record autumn crop which could minimise the loss only to some extent.

Land Planning and Drainage

Straight line planting continued to be favoured over master row system of planting in South and North Bank estates although contour drainage and land planning on the basis of grid survey has been accepted in general

for replacement and replanted areas. Considerable discussion followed everywhere during the seminars and meetings on the comparative efficiency of these two systems particularly where the slope percent is not considerably high. Tocklai has still been holding the view that master row system is the best to be followed for all such areas and some estates have just started rethinking and planning to adopt a modified method which needs further observation, and if acceptable, it will have to be followed up further.

Modified Contour planting in One Member Estate

A special point to mention about West Bengal is that several estates obtained excellent results where the carrying capacity of the old main and sub-main drains were increased. Dearth of good surveyors has been felt by the enthusiastic estates and the Advisory Officers could do very little in the absence of proper survey map.

Tea Husbandry

Pruning cycle

Although South Bank estates have been following 2-3 year cycles depending on the policy of the management concerned, a deviation from the conventional method of following one fixed pruning cycle in the entire estate has emerged with only a few progressive groups to the effect that suitability of various sections to the various pruning cycles had been considered. This has just taken a start. It is hoped that in course of years, grouping of sections depending on age, frame condition, shade etc., will be done and suitable pruning cycles will be considered separately for each group instead of following one cycle for the entire estate.

Cachar estates in general went in quest of crop and have been experimenting with 5-6 year pruning cycles. But, however, it has been observed that the cost of production could be substantially reduced if LP-UP-DS-UP was followed in teas suited to this type of pruning cycle.

North Bank had not yet come out of the shock of the previous year's drought and estates had reduced the percentage of light skiff and unprune particularly in areas with sandy soil. However, the pruning cycle continued to vary between 3 and 4 years. There is no appreciable change in the standard of pruning in North Bank except for some of the most interested estates .It is expected that the standard will go up very soon as a result of the successful seminars held on this subject and frequent advices given by the Advisory Officers.

A change in the thinking of the planters in the Dooars and Terai is noticeable following constant suggestions from the Advisory Officers and the yield which was adversely affected by two successive years of drought in the area. Drought prone estates are now rethinking to go for a comparatively severe form of skiff instead of leaving the teas unpruned or level-off skiffed. A suitable combination of light prune followed by unpruned or light skiffed in the second year with a deep or medium skiff in the third year and again another lighter form of skiff or unprune in the fourth year continued to be the general policy of most of the estates.

Pruning cycle in Darjeeling is largely based on the availability of the labour and is more oriented for maximum early crop. The estates are keen on a four or a five-year pruning cycle like LP-UP-DS-UP or LP-UP-LS-DS-UP and various other combinations.

Rejuvenation

While reports of success as well as failures in some cases after rejuvenation pruning have been received, it has become more and more clear that the causes of failure were mainly due to the deteriorated condition of the soil and/or due to wrong selection of the section.

In Darjeeling, although rejuvenation pruning was practised, infilling which is in fact a part of the package deal of rejuvenation is now gaining popularity in the area after the introduction of the Tea Board Subsidy Scheme for rejuvenation.

Plucking

In general, black plucking advocated for unpruned and light skiffed teas showed some gain in crop in the

beginning and was taken up with the great zeal. But in view of the exhausted look of the bushes due to continuous black plucking throughout the year, some estates are considering to introduce some modifications.

In droughty areas like Cachar and the Dooars, where black plucking was followed inspite of the loss of maintenance foliage, it proved disastrous and leaving of leaf in the beginning of the season to develop sufficient maintenance foliage was suggested. The same was true in stepped-up teas which suffered from the spring drought of 1976 in the Dooars.

Young Tea

Bringing up of young tea has not yet been fully standardised. Estates or group of estates have been trying their own methods depending on the availability of labour, economic condition and feasibility of the exercise. While it is expected that certain variations in step-up plucking combined with pegging or frame formative prune in the second year will continue to remain on the regional basis, a modified system is still awaited for the estates to take up.

Closer spacing as reported in the previous year has gained more popularity. Tocklai's thinking that the closest spacing of 60 cm within the hedges has been accepted. Most of the estates have been following this spacing and are trying to accommodate bushes between 16,000 20,000 per hectare.

Planting

Extension of tea has been given the top priority by the industry. Although there is need for young tea to come up in new areas, the estates have been constantly reminded of the need of uprooting and replanting, the progress of which has rather remained low inspite of the incentive given by the Tea Board. However, extension planting in marginal land from drainage point of view appears to be on the increase and if this trend continues unabated, this may be a potential danger for future.

Propagation

(a) **Clonal selection**

Enthusiasm in the selection of new clonal material is a positive change worthy of mention during the year under review. A number of estates have been keen to take the advantage of Tocklai's selection scheme recently introduced by the Plant Breeder and assisted by the Advisory Department. Regular requests have been received from the estates who are uprooting their old areas to help them in preservation of suitable germ plasm for future of the industry.

(b) **Vegetative Propagation**

Overhead shade continued to gain popularity and there has been a realisation that instead of a single and large overhead shade, smaller ones to cover one or two beds with inclined surface to allow more north light and to reduce drip damage is more suitable.

Even in droughty areas of Dooars, TV 9 which has not stood the drought in the past is still being multiplied at an alarming rate, the next preferable clone there being TV18 which is vigorous and easy to grow. The Advisory Officers emphasised the need to include other clones with some quality which are likely to grow comparatively better in such areas.

Three more clones were awarded interim certificate for Darjeeling, thus bringing the total to ten. This is expected to create more interest in the vegetative propagation work.

(c) **Seed**

Demand for biclonal stock continues. Estates are more keen to establish Tocklai recommended biclonal seed baries of stock 397, 449 and 450. Seeds of stock 203 have been used by estates in Cachar and some other areas.

Fertilizer

(a) **Nitrogenous Manures**

The danger of over manuring beyond 135 kg N/ha has caught the attention of the estates and there is now a growing tendency to stop over manuring. Some of the estate managers who had manured at a very high rate have ultimately tended to reduce their nitrogen application on an experimental basis.

Unlike Assam, in the Dooars nitrogen has rarely been applied beyond 135 kg/ha.

Although Tocklai has not yet recommended the application of nitrogen in split doses, it still appears to be favoured by some in the Dooars, Darjeeling, Cachar as well as in Assam.

(b) **Potash manuring**

Potash manuring on the basis of soil analysis is still continuing all over Assam. Although discriminatory

application of potash on the basis of soil test has not been finally recommended for Dooars, some estates are applying potash as remedial dressings.

(c) Foliar Application of Urea and Zinc

Foliar application of urea, particularly in the droughty areas and in the estates known to suffer from waterlogging during the rains seems to be on the increase.

Foliar application of zinc has been giving mixed results, nevertheless, its application continued during the period.

(d) Manuring of Young Tea

There has been no change in the manuring of young tea in Assam where most estates continued to remain liberal towards young tea manuring particularly in pegged tea.

In the Dooars, however, young tea was mostly manured as recommended by Tocklai except for a few estates who applied higher rates.

Weed Control

Activities under weed control remain unchanged during the year in most of the areas except that more and more estates have been joining the herbicide club and more areas have gone under chemical weed control.

Polygonum chinense, *Setaria spp.*, *Diascoria spp.* continued to remain practically unvulnerable to the chemicals used so far and in cases, had to be uprooted by hand.

Mulching

As reported earlier, the first preference for mulching went to the young tea in all over North East India. Due to shortage of green material, some estates went for paddy straw with additional dose of 20 kg N/ha as recommended. A word of caution was given to leave about 10 cm from the collar of the young tea unmulched.

Shade

After long years, there appears to be some awakening for reshading the poorly shaded teas or those with no shade. However, activity in thinning out shade rather than reshading was more in the North Bank of Brahmaputra Valley. The choice of shade trees still continued to be limited. *Dalbergia sericea* introduced as a new shade in the South Bank has not yet gained its footing. Efforts are still on to find ways for better germination of its seed.

In the Dooars, reshading was rather slow. Wherever it was taken up, *Indigofera teysmanii* was favoured. The Advisory Officers did not fail to caution these estates not to rely too much on *Indigofera* alone, but to go for the permanent ones also. In young tea area, however, permanent shade trees were employed.

Reshading of lower elevation estates in Darjeeling had received a set-back due to the destruction of the shade trees by the labourers. It is hoped that proper understanding and good efforts may change the situation. In blister prone elevation in Darjeeling however, shade was removed.

Pest and Disease

(a) Pest

In the South Bank, incidence of red spider, scarlet mite was more in Golaghat and Nowgong during the year under review. Sporadic cases of looper and bunch caterpillars were reported from Golaghat, Doom Dooma and Sibsagar sub-areas. Green fly also was more common.

In North Bank, heavy incidence of thrips was most noticeable. Looper was significantly less in the areas known to suffer from it. Cockchafer was found in areas where it was not seen before but the incidence was not heavy. It is, however, true that in most cases precautionary measures were taken against cockchafer, particularly in young clonal plantations. Red spider was unusually heavy in the North Bank. The green beetle (*Astychus chrysochlorus*) was seen throughout.

Mites were problematic in certain estates of Cachar. The areas covered by prophylactic spraying were, however, less affected. Attack of thrips was severe in many estates affecting the flush considerably. *Microcerotermes* was still a major pest in the district and the progressive estates were always careful to treat them in the year of pruning.

In West Bengal, thrips and scarlet mite infestations were particularly severe during the droughty period while red spider appeared when the drought was over. Thrips seem to be increasing in the Dooars and Terai.

Helopeltis had caused concern for the estates neighbouring the forest.

(b) Disease

In addition to the general incidence of black rot and red rust, a special mention may be made of blister blight in Upper Assam, which was particularly high.

The incidence of black rot was less and it appeared also late perhaps due to prolonged drought and die-back of skiffed teas in the North Bank. There, red rust is now a problem of a few estates only.

In Cachar, black rot caused considerable crop loss in estates who could not spray timely. Some estates reported satisfactory results from spraying during the crucial stage of development of this fungus from the resting stage. The areas encircled by bamboo forests and jungles always suffered more and as such the estates were advised to clean the jungle from the surrounding areas, at least upto a distance of about 45 metre.

Red rust and black rot continued to be the major diseases, though some estates are practically free from black rot in West Bengal.

Advisory Out-Station Plots & Experiments

The plots at the outstations and at Tocklai were maintained for distribution of cuttings of Tocklai release clones to the member estates, for conducting some look-see trials and to continue with the clonal proving project.

(a) **General**

Bushes in plots at Nagrakata were again severely affected by drought during 1975-76 spring. Post drought observation on the recovery of different clones were taken in Agricultural trials. Even the seed bari at Nagrakata was severely affected by drought and as a result only a small quantity of Nanda Devi seed was harvested.

(b) **Release of Tocklai Clones**

The details of distribution of cuttings, generative clones and seeds from various outstations and Tocklai to member estates are given in Table 2.

Table 2. Distribution of cuttings, scions, generative clones and seeds from various out-stations and Tocklai.

Out Stations	V. P. Cuttings	Scions	Generative cuttings	Generative scions	Plants	Seed
South Bank (Tocklai)	278,630	1,094	8,000	8,10	—	—
North Bank	156,470	884	—	—	—	—
Cachar	145,140	220	—	—	—	—
Dooars & Terai	460,390	2,318	12,005	1,510	—	10 kg of stock 378

(c) **Green Leaf**

Green leaf harvested from different outstation plots are stated below :

North Bank	:	3,495 kg
Cachar	:	5,414 kg
Nagrakata	:	23,585 kg

(d) **Experiments**

The following trials were in progress at Nagrakata Branch.

(i) Agricultural trials with different clones (1967/68)

(ii) Agricultural trials with different clones (1973/74)

(iii) Nitrogen response to different clones (1970/71)

(iv) Biclonal stock trial (1974/75) with stock 460, 461, 462, 463, 464, 449 (already released), 378 (already released for Darjeeling) and clone TV1.

(e) **Quality Testing Scheme (Dooars)**

Five clones were offered for testing in 1975 and these were planted out in the plots during autumn 1975. In addition, fresh cuttings of 4 Kopati Clones were received from North Bank, Assam and were planted in the nursery.

Routine work continued in 1969/70, 1971, 1973, 1974 and 1975 trials.

(f) **Clonal Proving Station, Darjeeling (Ging T.E.)**

The details of the trials conducted so far at the clonal proving station, Darjeeling are presented below :

Table 3. Details of experiments in clonal proving station, Darjeeling.

Sl. No.	Trial No.	Year of planting	No. of clones tried	Seed jat tried	Certified	Remarks
1.	A	1967	19	—	7 Clones	Under trial
2.	B	1968	7	—	3 Clones	,,
3.	C	1969	6	1	Under trial	,,
4.	D	1970	6	1	,,	,,
5.	E	1971	6	—	,,	,,
6.	F	1973	8	—	,,	,,
7.	G	1974	7	—	,,	,,

During the year 873 samples were manufactured and nt to tasters for their comments. No new planting was rried out. Three clones (RR.4/5, B.668 and TV14) ere released to the industry with interim certificate.

g) **Field Experiments on Tea Estates**

During 1975 a number of experiments on rejuvenation, ıfilling, plucking, NPK manuring etc. were continued. A complete and detail list of these experiments, conducted by this Department, is given in Appendix A.

The number of experiments conducted in various listricts during 1975-76 is given below :

South Bank	: 20
North Bank	: 12
Cachar	: 12
Dooars & Terai	: 30
Darjeeling	: 13

(h) **Area Scientific Committee Meetings/Seminars**

There are nine Area Scientific Committees in the tea districts of North-East India. The number of meetings held in the various districts is given below :

South Bank East	: 3
South Bank Central	: 1
South Bank West	: 3
North Bank East	: 2
North Bank West	: 2
North Bank East and West Joint	: 2
Cachar	: 3
Dooars	: 4
Terai	: 3
Darjeeling	: 4

With the Area Scientific Committee meetings, open sessions were also held for the planters of the area to discuss the local problems. These proved to be useful platforms for free exchange of ideas between the planters and the Scientific Staff. These open sessions were very well attended. The details of the Seminars held during 1975-76 are given below :

South Bank East	: One seminar on Agro-chemicals.
South Bank Central	: One Seminar on Continuous manufacture.
South Bank West	: One Seminar on Agricultural aspects.
North Bank East and West	: Two Seminars on Engineering & Manufacture. Four Seminars on Pruning Policies.
Cachar	: One Seminar on Plucking. Two Seminars on Agricultural aspects
Dooars & Terai	: One Seminar on Drainage. One Dooars & Terai Joint Seminar on Agricultural aspects. One Dooars & Terai Joint Seminar on Engineering & Manufacture.
Darjeeling	: One Seminar on Choice of planting material, raising of V. P. nursery & planting of new extension and uprooted areas. One Seminar on Engineering & Manufacturing problems.

(i) **Lecture Courses**

Three courses, each of five days duration, on "Surveying & Drainage" for the planters were held during the year. The courses were well attended.

Summary of Results

Summaries of a few interesting experiments conducted by this Department are given below :

(a) **Infilling Experiments**

(i) **Dooars and Terai (Nos. D 37, D 40, D 41,**

(TR 4), infilling with seedling at double the number of plants per vacancy plus one also produced significantly higher crop over no infilling.

However, inspite of substantial increase in yield due to infilling over no infilling, in two out of three experi-

Foliar application of Zinc

(i) **Assam including Cachar (Nos. AS 109, 12, AS 115, AS 121, AN 117, C 40 and C 41):** Seven riments were conducted, one each in Panitola, on, Doimukhia, Bokakhat, Monabari, Silcoorie and gai Tea Estates.

ut of these seven experiments significant difference ield due to Zinc application were observed in two experiments only. In North Bank (AN 117), 50 kg. Zinc/ha increased the yield by 10.4% over no Zinc. This increase, however, was not significant. Application of Zinc @ 12.5 and 25 kg/ha decreased the yield in that experiment compared to no Zinc treatment. This reduction was significant. In South Bank (AS 115), application of Zinc sulphate @ 12.5 and 50 kg/ha significantly increased the yield over control by 13.8% and 13.2% respectively.

Table. 3. Yield of made tea in kg/ha during 1975.

Expts. / reatment	AS 109	AS112	AS 115	AS 121	AS 117	C 40	C 41
= No Zinc	1567	1628	3005	1617	2435	2489	2249
= 12.5 kg Zinc/ha	1638	1660	3420	1667	2230	3012	1947
= 25kg Zinc/ha	1605	1658	3155	1857	2087	3033	2496
= 50 kg Zinc/ha	1544	1592	3402	1893	2688	2957	2321
S. D. (P=.05)	NS	NS	223	NS	316	NS	NS
V. %	6.19	10.65	3.48	5.81	6.70	7.25	23.05

ii) **Darjeeling (Nos. DJ 32 and DJ 33) :** Two eriments were conducted in Darjeeling one in Arya E. and the other in Sungma T. E.

Foliar application of Zinc sulphate at 50 kh/ha increased the yield significantly over other treatments which did not differ significantly amongst themselves at Surynia T. E. (Dj. 33).

Table. 4 Yield of made tea in kg/ha during 1975.

Treatment \ Experiments	Dj 32	Dj 33
T_1 = No Zinc	1069	1368
T_2 = 12.5 kg Zinc/ha	1073	1401
T_3 = 25 kg Zinc/ha	978	1456
T_4 = 50 kg Zinc/ha	1060	2098
L. S. D. (P = .05)	NS	393
C. V. %	11.22	12.44

iii) **Dooars (Nos. D 52, D 53 and D 54):** Three eriments were conducted in the Dooars one each in rtick, Baradighi and Bhogotpore Tea Estates.

Zinc sulphate at various rates tried in these experients could not produce singificant increase in yield er control. However, on an average, 12.5 and 50 kg /ha increased the yield by 4.3 and 1.8 per cent resctively over no Zinc.

(d) **Plucking Experiments (Nos. AS 126, AS 3, C 45, D 58, D 59, D 60)**

Six experiments (3 in Assam including Cachar and in Dooars) on different methods of Plucking were nducted.

(i) Assam : In experiment No. AS 133, the treatment (T_1) Pluck black to janam gave significantly higher crop than standard plucking (T_2), while T_2 produced significantly higher yield over T_1 in experiment No. AS 126.

(ii) Dooars : In one of the Dooars experiments (D 59) Standard plucking (T_2) produced significantly higher yield over black plucking T_1.

Over all results indicated that pluck to janam yielded more crop over black plucking. In the unpruned plots black plucking gave more crop. These differences were, however, not always significant.

Planting and Spacing

One factorial experiment (B. 8/1) was initiated in 1966, with four plant-to-plant spacings (at a constant row spacing of 120 cm), three nitrogen levels (100, 200, and 300 kg/ha) and two clones (TV 1 and TV 9). As in the past, the yield interactions of spacing × clones, and spacing × nitrogen were not significant.

The data on spacing in 1973 and 1975 showed that all the closer plant spacings (22.5 cm, 30 cm, and 45 cm) gave significantly higher yield than the widest spacing (90 cm). In 1974, the closest spacing of 22.5 cm gave significantly higher yield than the 90 cm spacing only.

Table 1. Mean effect of different spacings on yield of clonal tea.

Spacing Treatment (cm)	Plant Population/ha	Yield of made tea (kg/ha) 1973 L. P.	1974 D. S.	1975 M.S.
120 × 22.5	37,040	1687	2215	2108
120 × 30.0	27,780	1441	1882	1850
120 × 45.0	18,520	1462	1875	1809
120 × 90.0	9,260	1166	1639	1552
L. S. D. (5% level)	--	271	261	231
C. V. (%)	-	22.1	16.1	14.8

Another trial (B. 8/2) started in 1966, has six plant-to-plant spacings (60 cm, 75 cm, 90 cm, 120 cm and doubletons at 75 cm and 90 cm) with a constant row spacing of 120 cm. Khorijan jat tea was used in this trial.

Yield differences between spacings were significant in 1973, 1974, and 1975 (Table 2). The spacings of 120 cm × 75 cm × 75cm, 120 cm × 90 cm (doubleton), and 120 cm × 60 cm were at par in 1973. In 1974 120 cm × 75 cm × 75cm spacing gave significantly higher yield over 120 cm × 60 cm but was at par in 1975. The 120 cm × 75 cm × 75 cm spacing was always significantly superior to 120 cm × 90 cm, 120 cm × 75 cm and 120 cm × 120 cm spacings.

In one other experiment (B. 104) which was started in 1975, the effects of five spacings (Table 3) on the yield of two jats of tea at three levels of nitrogen were studied. Except in 1973, the yield differences between various spacings were not significant.

A new experiment in a systematic fan design (B.32.2) covering spacing range of 15 cm to 150 cm was planted

Table 2. Effect of different spacings on the yield of jat tea.

Spacing Treatment (cm)	Plant Population/ha	Yield of made tea (kg/ha) 1973 L. P.	1974 D. S.	1975 M. S.
120 × 120	6,944	1042	1505	1352
120 × 90	9,259	1115	1635	1422
120 × 90 (doubleton)	18,518	1182	1703	1438
120 × 75	11,111	1094	1562	1371
120 × 60	13,888	1198	1682	1499
120 × 75 × 75	13,675	1281	1844	1587
L.S.D. (5% level)	--	127	155	135
C. V. (%)	—	7.3	6.2	6.2

Table 3. Mean effect of different spacings on the yield of made tea.

Spacings (cm)	Plant Population/ha	Yield of made tea (kg/ha) 1972 L. P.	1973 D. S.	1974 M. S.	1975 M. P.
120 × 120	6,944	1347	1163	1316	501
150 × 98	6,802	1300	1205	1330	562
150 × 75	8,888	1324	1070	1190	499
150 × 60	11,111	1429	1295	1418	580
120 × 60	13,888	1448	1235	1336	533
L. S. D.(5%)		N. S.	122	N. S.	N.S.
C. V. (%)		20.7	16.2	22.8	35.4

on 25 arcs each having different spacings and replicated four times at Borbhetta in July, 1974. The plants were damaged by hail in early 1975 and could not be decentred till January, 1976 because of low starch reserves. They were allowed to grow freely in 1975. Observations on growth and microclimate were recorded in 1975 and the pruning weight was recorded at the time of decentering in January, 1976. The data on growth are graphically represented in Fig. 1 and 2. The spacing corresponding to each arc is given below.

Arc. No.	Spacing	Arc. No.	Spacing	Arc. No	Spacing	Arc. No	Spacing
1	13.5	7	25.3	13	47.3	19	88.7
2	15.0	8	28.1	14	52.6	20	98.5
3	16.6	9	31.2	15	58.4	21	109.3
4	18.5	10	34.6	16	64.8	22	121.4
5	20.5	11	38.4	17	72.0	23	134.8
6	22.8	12	42.6	18	79.9	24	149.7
						25	166.2

The following conclusions can be drawn from the results obtained so far :

The plants attained maximum height at 42 cm plant to plant spacing.

Maximum number of leaves per plant was recorded at 72 cm plant to plant spacing.

Close spacing reduced the number of branches per plant. Maximum number of branches per plant was recorded at a plant to plant spacing of 72 cm.

The collar diameter was progressively reduced by close spacing of upto 38 cm. There was practically no difference in spacings ranging from 42 cm to 166 cm.

Total pruning weight and weight of leaves in the pruning was reduced both by close and wide spacings. Maximum pruning weight and weight of leaves per plant was recorded in the 65 cm and 72 cm spacings respectively.

ıcking

In this experiment (B. 112/1) the effect of different thods of plucking on the yield of tea is being studied ce 1971. In 1972, 1973 and 1974 plucking black to ıam (black plucking) treatment (T_1) gave significantly ghest yield over all other plucking treatments except (yield inclusive of broken back portion) in 1972 and 74 (Table 4). In the light pruned year of 1975, all eatments were plucked uniformly as per the Tocklai ndard method. No significant deleterious effect of ack plucking done from 1971 to 1974 was observed on e 1975 yield.

ble 4. Effect of plucking methods on the yield of made tea.

Plucking Treatment	Yield including broken back leaf (kg/ha) 1972 L. P.	1973 U. P.	1974 U.P.	1975 L. P.
Pluck black to janam	1851	2701	2831	1669
Pluck standard leaf, no breaking back.	1325	1948	2143	1760
Pluck standard leaf, and break back to janam.	1838	2338	2708	1721
Pluck standard leaf over fish leaf, and no breaking back.	1169	1708	2104	1773
Pluck standard leaf over fish leaf, and break back to level off.	1617	2214	2442	1818
L. S. D. (5%)	134	163	166	N. S.
C. V. (%)	6.2	5.4	4.9	4.0

Plant Nutrition

A number of experiments to study the response of tea to different plant nutrients are being conducted at Borbhetta. The results of some of these experiments are briefly discussed as under :

Nitrogen

In one factorial experiment (B. 8/1), initiated in 1966, three nitrogen levels, (100, 200, and 300 kg/ha) were included along with four spacing treatments and two clones. The data on the main effects of nitrogen levels presented in Table 5 show that there was no yield difference between 200 and 300 kg N/ha in 1970, 1971, and 1972. However, nitrogen application at 300 kg/ha level tended to be deleterious in 1973 and this was confirmed statistically in 1974 and 1975. Similarly, 200 kg N/ha level gave significantly higher yield in 1971 and 1972, but it was on par with 100 kg N/ha in 1973, 1974 and 1975.

Table 5. Effect of different levels of nitrogen on the yield of tea.

Nitrogen level (kg/ha)	Yield of made tea (kg/ha) 1970 D. S.	1971 M.S.	1972 L.S.	1973 L. P.	1974 D.S.	1975 M.S.
100	1098	1336	2148	1484	1990	1897
200	1331	1690	2516	1544	2066	2028
300	1360	1628	2438	1289	1659	1565
L.S.D. (at 5% level)	N.S.	267	262	N.S.	226	200
C.V. (%)	27.3	23.3	15.0	22.1	16.1	14.8

In another experiment (B. 104), the effect of three levels of nitrogen (90, 135, and 180 kg/ha) on two jats of tea at 5 different spacings is being investigated. After an initial boost in yield levels of the jat tea in 1961 and no increase between 1962 and 1968, the higher levels of nitrogen were found deleterious in 1969 and onwards. The results of 1972 to 1975 (Table 6) show that 90 kg/ha level gave significantly higher yield than 135 and 180 kg/ha levels in all the years except 1974. Application of 180 kg/ha reduced the yield significantly in all the years.

Table 6. Response of jat tea to different levels of nitrogen application.

Nitrogen level (kg/ha)	Yield of made tea (kg/ha) 1972 L.P.	1973 D.S.	1974 M.S.	1975 M.P.
90	1462	1289	1361	596
135	1370	1174	1313	540
180	1276	1118	1250	481
L. S. D. (at 5% level)	59	51	56	31
C. V. (%)	9.6	9.5	9.5	12.8

In another factorial experiment under no shade (B. 5.1) the response of Tingamira jat tea at four levels of nitrogen, two levels of phosphate and two levels of potash is being studied since 1961.

Table 7. Effect of four levels of nitrogen on the yield of made tea of Tingamira jat.

Nitrogen Level (kg/ha)	Yield of made tea (kg/ha) No shade			
	1972 L.P.	1973 U.P.	1974 U.P.	1975 L.P.
0	1134	1153	1234	798
50	1348	1522	1765	1160
100	1148	1434	1808	1093
150	854	1135	1519	819
L. S. D. (at 5% level)	87	88	109	88
C. V. (%)	10.9	9.4	9.6	12.7

The results of 1972 to 1975 presentedi in Table 7 show that 150 kg/ha level had deleterious effect on the yield of tea.

In summary, the experiments with nitrogen suggested that tea responds well only upto a certain level of nitrogen application beyond which the response is negative.

Phosphorus

A factorial experiment (B. 105) is being conducted since 1960 to study the response of TV 2 clone to four levels (0, 45, 90 and 180 kg/ha) of P_2O_5 applied as single superphosphate. The data (Table 8) indicate that application of P_2O_5 did not affect the crop yield significantly in all but two years. In 1970 yield tended to reduce with increase in P_2O_5 application, the 180 kg/ha level being significantly inhibitory of yield. Later, P_2O_5 application tended, but not significantly, to enhance the yields. In 1974, there was significant response to 90 kg/ha level.

Table 8 Effect of different levels of phosphate on the yield of tea.

P_2O_5 (kg/ha)	Yied of made tea (kg/ha) 1970 L.P.	1971 D.S.	1972 M.S.	1973 L.P.	1974 D.S.	1975 M.S.
0	1588	1708	2467	1697	1865	1786
45	1576	1744	2562	1730	1977	1824
90	1493	1790	2675	1796	2067	1826
180	1374	1680	2594	1706	1975	1711
L.S.D. (at 5% level)	109	N.S.	N.S.	N.S.	117	N.S.
C. V. (%)	10.2	10.2	9.1	8.6	8.4	11.7

This reversal in the trend of phosphorus response could be attributed to the effect of chemical weed control which eliminates weed competition and encourages production and development of a mass of surface feeder roots. Another possible reason for the increased phosphorus response is the interaction effect of zinc which is being applied as zinc sulphate regularly since 1970. Such interaction effects are not uncommon in other crops.

In another experiment conducted on Tingamira jat planted in 1961, the effect of mulch and chemical weed control on the response to various levels of phosphorus application is being investigated.

Table 9. Effect of phosphorus, mulch and chemical weed control on the yield of tea.

Treatment		Yield of made tea (kg/ha) 1973 L.P.	1974 D.S.	1975 L.S.
Phosphorus	0 kg/ha	1468	2140	2031
	50 ,,	1474	2214	2047
	100 ,,	1463	2186	2048
	150 ,,	1506	2181	2084
	200 ,,	1480	2182	2108
L. S. D. (at 5% level)		N.S.	N.S.	N.S.
C. V. (%)		8.5	7.0	7.9
Mulch	No mulch	1480	2162	2017
	Guatemala mulch	1477	2200	2110
Weed Control	Cheeling	1483	2173	2036
	Chemical weed control	1473	2188	2091
L.S.D. (at 5% level		N.S.	N.S.	47
C. V. (%)		5.6	5.7	5.0

The data presented in Table 9 showed there were no significant yield differences between the various levels of phosphorus application and the interaction treatments of phosphorus, mulching and weed control,. It was only in 1975 that mulching and chemical weed control were significantly superior to no mulching and weed control by cheeling. That mulch and chemical weed control did not enhance response to phosphorus could be due to the relatively longer time it possibly requires for the development of significant amount of feeder roots and the subsequent influence on the response to phosphate.

Potassium

The response of clonal tea (TV 2) to potassium was studied in an experiment (B. 105) involving four levels of K_2O and P_2O_5 (discussed in response to phosphorus). Potassium was applied since 1960 at 0, 45, 90 and 180 K_2O kg/ha.

The results (Table 10) indicated that that there was significant response to K_2O upto 45 kg/ha. Application of higher levels of potash seemed to have no significant beneficial effect.

Table 10. Effect of different levels of K_2O on the yield of tea.

K_2O (kg/ha)	Yield of made tea (kg/ha) 1970 L. P.	1971 D. S.	1972 M. S.	Mean of 3 years	Yield of made tea (kg/ha) 1973 L. P.	1974 D. S.	1975 M. S.	Mean of 3 years
0	1279	1490	2289	1686	1495	1671	1555	1574
45	1530	1708	2555	1931	1779	1988	1780	1849
90	1596	1810	2652	2019	1803	2054	1880	1912
180	1625	1913	2803	2114	1854	2171	1933	1986
L. S. D. (at 5% level)	109	126	167	--	106	117	149	-
C. V. (%)	10.2	10.2	9.1	-	8.6	8.4	11.7	--

Zinc

In one experiment (B. 108/1.2) the effect of zinc is being studied since 1970 on Tingamira jat tea planted in 1958 and grown under medium shade. Zinc was applied as zinc sulphate at 24 kg/ha and the results (data not presented) showed that except in 1971, there was no significant response to zinc.

In another experiment (B. 1A/2.1) where clonal tea (TV 9) was planted in 1964, a study is being conducted to determine the level, method and frequency of application of zinc on mature tea. Zinc was applied to the foliage or soil at two rates and the application was given every year and once in three years. The results (Table 11) showed no significant differences amongst the treatments.

Table 11. Effect of different levels, method and frequencies of zinc sulphate application on yield of tea.

Zinc sulphate (kg/ha)	Yield of made tea (kg/ha) 1973 L.P.	1974 D.S.	1975 U.P.
1. No zinc	961	1346	1380
2. 12.5 kg -foliar application annually	1034	1429	1487
3. 25.0 kg- -do-	1052	1471	1436
4. 12.5 kg—foliar application once in 3 years (1974).	949	1387	1454
5. 25.0 kg— foliar application once in 3 years (1974)	944	1329	1390
6. 25.0 kg—Soil application annually.	900	1268	1304
7. 50.0 kg—Soil application annually	977	1363	1309
8. 25.0 kg—Soil application once in 3 years (1974)	966	1332	1413
9. 50.0 kg- -do-	977	1433	1589
L. S. D. (at 5% level)	N.S.	N.S.	N.S.
C. V. (%)	10.0	9.7	11.1

Experiments on quality

Effect of different levels of phosphate and potash on quality

Leaf from four phosphate and potassium combination treatments (applied at a constant nitrogen levels) of a manuring experiment (B. 105) with TV 2 clone was manufactured every week for 16 times in 1974 and 1975. They were tasted at Tocklai to determine the effect of phosphate and potash applied continuously over a period of 13 years on the strength, quality and valuation of C.T.C. teas.

Table 12. Mean score on strength, quality and valuation of C. T. C. teas as affected by phosphate and potassium.

Treatment N. P. K. (kg/ha)	1974 (DS) Strength	Qlty	Valuation	1975 (MS) Strength	Qlty	Valuation
135 0 0	75	76	6.81	66	61	7.17
135 180 0	74	74	6.76	71	66	7.44
135 0 180	73	72	6.61	66	61	7.16
135 180 180	71	71	6.59	70	63	7.17

The data (Table 12) suggest that application of phosphate and potash alone and in combination had no effect on the strength, quality and valuation of C.T.C. teas in 1974 and 1975.

Effect of Foliar Application of Zinc Sulphate on quality

Zinc was applied to Tingamira jat plant foliage as zinc sulphate at 6 kg/ha each time at four bimonthly intervals. Leaf samples were collected on 22 occasions at weekly intervals and the tea was manufactured in 1 kg rollers by C.T.C. method. The tea tasters' scores of the samples of 1974 and 1975 on strength, quality and valuation are presented in Table 13.

Application of zinc had no effect on the quality and valuation of tea in 1974 and 1975. However, it did significantly lower the strength of the liquor in 1974, but not in 1975.

Zinc sulphate did not affect quantity and colour of tip, strength, quality and valuation of the orthodox teas in 1974 and 1975 (data not presented).

Long Term Yield Trial of Tocklai Clones

The yield of the various Tocklai clones (planted in 1966-67) for [illegible] 1974 and 1975 is given in Table 14.

Table 13. Mean scores on strength, quality and valuation of C. T. C. tea as affected by zinc application.

Treatment	1974 (UP)			1975 (LP)		
	Strength	Quality	Valuation	Strength	Quality	Valuation
Water spray	74	73	6.66	68	60	7.19
ZnS_4O spray	67	69	6.42	66	60	7.18
L. S. D. (at 5% level)	5.4	N.S.	N. S.	N. S.	N.S.	N. S.

The mean yield data over the three year pruning cycle indicated that TV 14, TV10 and TV4 were at par and gave maximum yield. In the light pruned year of 1973, TV 14, TV9, TV4, TV11, TV7, TV 1 and TV10 were at par and they gave higher yields than other clones. In the deep skiffed year of 1974, TV 14 was significantly superior to all other clones except TV13. Thus, these results indicate the distinct superiority of TV 14 over other clones.

Table 14. Yield response of various clones to the pruning cycle.

Clone	Yield of made tea (kg/ha)			
	1973 L.P.	1974 D.S.	1975 M.S.	Mean 1973--75
TV 1	2062	1887	1714	1888
TV 2	1577	1552	1459	1529
TV 4	2151	1943	2155	2083
TV 6	1699	1807	1581	1696
TV 7	2100	1679	1747	1842
TV 8	1829	1765	1790	1795
TV 9	2184	1810	2056	2016
TV10	2031	1985	2357	2124
TV11	2112	2014	1987	2037
TV12	1790	1805	2348	1981
TV13	1938	2155	1834	1976
TV14	2335	2348	2313	2332
Betjan	1674	1763	1834	1757
LSD (at 5% level)	318	253	414	272
C. V. (%)	11.3	9.8	14.9	9.8

Drought Tolerance of clones

As 1975 (October 1974 to June 1975) was a droughty year (Table 15), the yield levels of different clones obtained in 1975 were compared with those obtained in the normal year of 1974 (October 1973 to June 1974). The fact that yield levels are generally high in the medium skiffed year than the deep skiffed year has been used to estimate clonal differences to drought tolerance. Failure to maintain high yield in medium skiffed year could indicate lack of drought tolerance. Inspite of drought in 1975 (medium skiffed year), TV 10, TV 12, TV 14, TV 11, TV 4, TV 9, TV 8 and TV 7 maintained higher or same yield levels as in the normal year of 1974 (deep skiffed year). The clones TV 1, TV 2, TV 6 and TV 13 gave lower yields in 1975 and they apparently are drought susceptible. Interestingly, TV 14 maintained higher yield levels in both the droughty and normal years, indicating its apparent adaptability to a wide range of weather conditions.

Table 15. Rainfall data for the years 1972-73, 1973-74 and 1974-75.

Month	Rainfall (mm)		
	1972-73	1973-74	1974-75
October	132	59	112
November	3	23	36
December	12	43	4
January	13	36	12
February	23	17	27
March	28	110	8
April	260	239	199
May	256	232	140
June	474	204	322
	1201	963	860

Weed Control

Various new herbicide products and formulations have been tested for their effects on weed control. Cifon (trade product of Dalapon), Weedar 96 (dimethyl amine salt of 2,4-D), Roundup and Probe received during the year certificates of approval of their use in tea.

Several new herbicide products have been tested during the year :

Asulox 40

In a screening trial, Asulox 40, reportedly active on grasses, was sprayed at postemergence on *Imperata cylindrica* (thatchgrass), one of the most problem weeds in tea, at 6, 7, 8, 9 and 10 litres total product/ha. The results showed that 8 and 9 l/ha rates were moderately effective for upto 70 days after spraying. These rates were also effective for a fairly good control of a mixed stand of *Imperata cylindrica* and *Arundinella bengalensis*. In another trial, Asulox 40 completely killed *Pteridium aquilinum*, a fern, at 8 l/ha.

Soil application of 7, 8 and 9 l/ha of Asulox 40 caused little or no toxicity to $1\frac{1}{2}$ year old clonal plants. Directed foliar application, however, caused mild to moderate toxicity to these young tea plants.

Oxitril CM

Oxitril CM, a broadleaf herbicide, was found to have no effect on *Borreria hispida*, the commonly occuring broadleaf weed in tea, at any of the four rates, 0.5, 1.0, 1.5 and 2.0 kg total product/ha, applied at postemergence. Neither did it show any activity on other weeds such as *Saccharum spontaneum*, *Mikania scandens* and *Drymaria cordata*. It, however, killed *Oxalis acetocella* only for a short period, after which regrowth occurred. Oxitril was fairly good on *Scoparia dulcis*.

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Besides Asulox-40 and Oxitril CM, — Destun, Strel, Ronstar, Brominal, Brominal Plus and TOK-E-25 were also screened and Ronstar and Destun which showed promise are under further testing.

Enhancement of Herbicide Activity

The effect of Triton AE (resins of synthetic esters 37.5% and iso-octyl-phenoxy-poloxethanol 12.5%), a new sticker, spreader and wetting agent on the activity of herbicides was tested under simulated rainfall conditions. As test species, the broadleaf weed *Borreria hispida* was used in study with 2,4-D (sodium salt 80%) and the perennial grass *Imperata cylindrica* was used in studies with dalapon (Dowpon 80%) and paraquat (Gramoxone). Approximately, 1.2 cm rainfall was simulated by spraying water on weed foliage at various time intervals after herbicide spraying. Triton AE was added at 0.06% concentration to the herbicide spray volume.

The data showed that the addition of Triton AE markedly increased the efficacy (activity) of 2,4-D sodium salt formulation applied at 0.4 and 0.8 kg a.i./ha (0.5 and 1.0 kg total/ha), particularly when rainwash was given for upto 4 hr. after herbicide application (Table 16). This increased activity was, however, not evident at 0.2 kg a.i./ha rate of 2,4-D. The activity of dalapon was also markedly increased at 3.2 kg a.i./ha (4.0 kg total/ha) but not at 1.6 kg a.i./ha rate. Triton AE however, had absolutely no effect on the activity of paraquat.

These findings indicate that the addition of Triton AE to a contact herbicide like paraquat (Gramoxone does contain an additive agent) will serve little purpose. However, its inclusion in the spray solution of translocated herbicides like 2,4-D and dalapon will be very useful and essential, particularly at higher rates, for greater herbicide activity. This is apprarently because of greater herbicide penetration into plant tissue and translocation from foliage to other plant parts. These results are also in confermity with the fact that the addition of nonionic surfactant like Triton AE will enhance penetration of polar herbicides like 2,4-D and dalapon through the waxy, nonpolar, cuticular layer.

Table 16. Effect of Triton AE on the activity of herbicides under simulated rainwash conditions.

Herbicide (kg or l a. i./ha)		Triton AE	*Weed control (%) Rainwash after herbicide spraying					
			30 min	1 hr	2 hr	3 hr	4 hr	8 hr
1. 2, 4-D	0.8 kg	No Triton	40	40	40	45	45	—
2. 2, 4-D	0.8 kg	Plus Triton	45	60	60	70	75	—
3. 2, 4-D	0.4 kg	No Triton	5	5	20	20	20	—
4. 2, 4-D	0.4 kg	Plus Triton	15	20	25	30	30	—
5. 2, 4-D	0.2 kg	No Triton	5	5	10	10	15	—
6. 2, 4-D	0.2 kg	Plus Triton	15	15	20	20	25	—
7. Dalapon	3.0 kg	No Triton	—	25	30	—	35	45
8. Dalapon	3.0 kg	Plus Triton	—	30	35	—	50	55
9. Dalapon	1.6 kg	No Triton	—	10	15	—	20	25
10. Dalapon	1.6 kg	Plus Triton	—	15	20	—	25	25
11. Paraquat	3.0 l	No Triton	—	80	80	—	—	—
12. Paraquat	3.0 l	Plus Triton	—	80	80	—	—	—
13. Paraquat	1.5 l	No Triton	—	65	65	—	—	—
14. Paraquat	1.5 l	Plus Triton	—	65	65	—	—	—

*Weed control was rated 4 weeks, 6 weeks and 2 weeks after application of 2,4-D, dalapon and paraquat respectively. As test species, *Borreria hispida* was used in case of 2,4-D and *Imperata cylindrica* in case of dalapon and paraquat.

•Control of Individual Weed Species

Mimosa invisa

Mimosa invisa is an important species for soil rehabilitation in tea. A field experiment was conducted to select herbicides which can effectively kill it after the rehabilitation period. Seeds of this species were sown and the plants were allowed to grow intensively before herbicides were applied.

Glyphosate, methazole and paraquat were found to be very effective initially (Table 17). They however failed to check regrowth of this plant at later periods. 2,4,5-T maintained fairly good control and checked regrowth more effectively. Its ability to suppress regrowth between 3 and 5 weeks (effect lost only by 10%) is markedly better than that shown by glyphosate, methazole, and paraquat (effect lost by 25%). This indicates that

although all herbicides excluding paraquat are translocated herbicides, 2,4,5-T has greater long-term activity on this broadleaf species. However the nonavailability of 2,4,5-T for commercial purposes precludes its use in tea.

2,4-D, in any salt formulation is only partially effective. Although the addition of urea and Triton to spray solution slightly enhanced its activity initially, it did not show up later on. TOK E-25 had no effect and it even reduced paraquat activity. The use of Strel which had a fairly good activity only initially, is seriously limited by its rather high rate and hence cost of application.

Further studies are underway with glyphosate, methazole and paraquat herbicides.

Table 17. Effect of various herbicides on the control of *mimosa invisa* weed.

Herbicides	Rate/ha (total formulation)	% Control 1 week	3 weeks after spraying	5 weeks	8 weeks
2,4-D (Na salt)	2 kg	20	35	15	10
2,4-D (Na salt + Urea 1%)	2 kg	35	45	20	15
2,4-D (Na salt + Triton AE 0.6%)	2 kg	30	25	15	10
2,4-D (dimethlamine salt – Weedar 96)	2 l	30	45	15	10
2,4,5-T	4 l	80	95	85	80
Paraquat (Gramoxone)	3 l	85	95	70	65
Methazole (Probe)	4 kg	90	100	75	70
Glyphosate (Roundup)	4 l	100	100	75	70
Strel	20 l	85	90	60	40
TOK E - 25	6 l	10	20	5	0
TOK E - 25 + Paraquat	6 + 3 l	85	90	50	25

Control of Scoparia dulcis

Scoparia dulcis is a predominat broadleaf weed particularly in young tea and nursery. Poteulture studies were conducted to determine herbicides that can effectively control this weed. Young seedlings of 5 to 7 cm tall were planted in Polyethelene sleeves and grown for about 6 weeks until they were about 15 to 20 cm when the herbicides were sprayed as postemergence on the foliage. The experiment was repeated once and the only change made in experiment II was inclusion of glyphosate in place of nitrofen.

The data (not presented) showed that methazole and glyphosate were extremely effective for control of *Scoparia dulcis* or even upto 11 weeks. Though the effect of paraquat, a contact herbicide, was initially good, it was not shown up later on. Regrowth in paraquat treatments was almost complete by 11 weeks. Actril DS was moderately effective. Nitrofen and both formulations of 2,4-D had little or no effect. Addition of urea to 2,4-D had no effect initially but increased the herbicide activity slightly only at a later stage. A detailed study is underway on the effect of glyphosate and methazole.

Biology of Weed Species

These studies greatly help in understanding the biological, soil and environmental factors affecting the propagation and growth of weed species in determining the proper time or stage of growth at which the weed is more susceptible to herbicide activity and thus possibly reducing the rate of application of the herbicide without affecting its activity and selectivity. A proper knowledge and understanding of the biology of weed species is essential for a successful and economical weed control programme.

Biology of Oxalis acetosella

Oxalis acetosella Linn., a prominent broadleaf weed in tea, has a tap root system just below the leaf base around which a cluster of 70 to 100 bulbils are formed. These bulbils serve as the most prolific means of propagation. They can remain dormant in the soil and germinate later. This poses a sizeable problem in tea growing areas.

A replicated poteulture experiment was conducted to study the rate of multiplication of different types of bulbils. The propagating material, separated into four groups, mature bulbils, semi-mature bulbils, very young bulbils and young buds which later develop into bulbils was planted in potted soil. Germination data was recorded at different time intervals. Mature bulbils had a higher percentage of germination (82%) after only five weeks of planting (Table 18). Very little germination (0–14%), even after three months of planting was

observed in the other types of planting material. It was thus evident that the pea-sized round to oval-shaped mature bulbils which drop off to ground easily when plant is uprooted, provide a good propagating material for *Oxalis acetosella*.

In another trial, plants grown from mature bulbils were allowed to complete their growth cycle. During this growth period the emergence of various types of new bulbils was observed. Mature bulbils began forming 16 weeks after planting (of mother mature bulbils) and their most prolific formation occured at 18 weeks after planting (Table 19). Other types of bulbils and buds were formed early in the growth period and these apparently matured to become mature bulbils.

Thus, these studies suggest the following :

(1) Mature bulbils provide very good propagating material for *Oxalis acetosella* weed.

(2) These mature bulbils begin to form at about 16 weeks after planting.

(3) It is, hence, essential to check growth of this weed and prevent formation of mature bulbils by using proper herbicide(s) no later than three months after germination.

Table 18. Germination of various types of propagating material of Oxalis acetosella.

Propagating material	Germination, (%) Weeks after planting					
	5	7	9	10	12	16
Mature bulbils	4	56	78	82	86	88
Semimature bulbils	2	4	6	6	6	6
Very young bulbils	0	0	2	4	6	8
Buds	0	0	4	8	10	14

Table 19. Rate of formation of different type of bulbils or buds from plants of mature bulbils.

Type of bulbils or buds formed	No. of bulbils or buds formed/plant Weeks after planting						
	12	14	16	18	20	22	24
Mature bulbils	Nil	Nil	20	120	119	115	90
Semimature bulbils	14	23	23	3	2	2	Nil
Very young bulbils	44	42	44	Nil	Nil	Nil	Nil
Buds	10	7	8	4	3	4	Nil

Effect of continuous application of herbicides on quality of tea

In this experiment (B. 27) paraquat (Gramoxone 3 l/ha), 2,4-D + dalapon, (1 kg + 3.5 kg/ha) and glyphosate (Roundup 3 l/ha), are applied continuously every year. Sixteen weekly leaf samples were collected to determine the effect, if any, of application of these herbicides on the quality of C. T. C. manufacture tea. The data on mean scores indicated that none of the herbicide treatments affected the strength, quality, and valuation of tea (data not presented).

Studies on soil potash

The cumulative uptake : time relationships, worked out from the exhaustive cropping trials with *Pennisetum pedicellatum* show that :

(I) As far as the virgin soils are concerned, the rate of uptake up to ninth cut (each cut at an interval of 4 weeks) is much higher in the case of "high" available potash status soils as compared to either "medium" or "low" available potash status soils. However, rate of uptake does not differ much between "medium" and "low" potash status soils.

(II) So far soils from the long-term manurial experiments are concerned, the rate of uptake up to ninth cut has been found to be highest with the highest levels of application of potash in the past. However, the rates of uptake of potash differ between 2-1-1 N-P-K and NK mixtures applied. Potash yields (dry matter × potash concentration) in the case of 2-1-1 N-P-K mixture follow the order of manuring $N_{224}\ P_{112}\ K_{112} > N_{180}\ P_{90}\ K_{90} > N_{90}\ P_{45}\ K_{45} > N_0\ P_0\ K_0$, whereas in case of NK mixtures it follows the order $N_{90}\ K_{180} > N_{90}\ K_{90} = N_{90}\ K_{45} = N_{90}\ K_0$.

(III) Cumulative potash uptake up to ninth cut, irrespective of virgin or long-term manured soils, follows the increasing order, "high" available potash status soils > "medium" available potash status soils > "low" available potash status soils.

The cumulative uptake : K-intensity relationships, worked out from the exhaustion experiment shows that:

(i) Potassium buffer capacity (i.e., cumulative K-uptake from 100g soil per unit change in activity ratio $(AR)_0$ or K - intensity during any cropping period) is inversely related to the K - intensity of soils irrespective of virgin or long-term manured series, the regression equation being $Y = 53.92 - 1297\ X$ ($r^2 = -0.56$), Y is potassium buffer capacity (BC) and X is potassium intensity $(AR)_0$. Changes in K-uptake and soil K—intensity during cropping, in general show that: (a) "high" potash soils with large K-saturation of exchange sites (i.e., high K-intensity) have lower buffer capacities up to ninth month of cropping and (b) "low" potash soils with smaller K-saturation of exchange sites (i.e., low K-intensity) have higher buffer capacities over the same cropping period, Cumulative potash residues from long-term manuring in the past indicated a decrease of the potassium buffer capacity (BC) of Borbhetta soils.

(ii) All soils, irrespective of virgin or manured ones, tend to show a decrease in K-intensity values corresponding with vigorous K-uptake initially. However, this change in K-intensity of soils with exhaustive cropping differs between "high" and "low" potash status soils, and the differential behaviour could be related to the rate of change of the cumulative potash uptake.

The above *interim* information suggests that cumulative potash uptake under exhaustive cropping is related to potassium -intensity which, in turn, is negatively related to potassium buffer capacity of soils. This experiment will be in progress until soils show signs of exhaustion finally.

Studies on soil phosphate

Cumulative phosphate uptake : time relationships worked out from the exhaustion cropping trials with *Pennisetum pedicellatum* shows that :

Cumulative phosphate uptake increases linearly up to seventh cut (period of cropping being seven months and each cut taken at an interval of about a month) in the case of both virgin soils (from different regions) and long-termed manured soils from Borbhetta. In this experiment virgin soils were manured with phosphate (P_2O_5) at rates 0, 60, 120 and 180 kg per hectare, whereas long-term manured ones did not receive any additional phosphate prior to exhaustive cropping. In the latter case phosphate residues from long-term phosphate manuring were cumulatively built up at application rates of 45, 90, 112 and 180 kg per hectare.

Cumulative phosphate uptake : phosphate application rate relationships show that:

(i) The rate of uptake of phosphate up to seventh cut in the case of virgin freshly manured soils does not

significantly vary between levels of application 0, 60, 120 and 180 kg P_2O_5 /ha, although the quantum of uptake consistently follows the increasing order, $P_{180} > P_{120} > P_{60} > P_0$, all throughout the period of cropping.

However, both rate and quantum of uptake of residual phosphate from long-term manured soils have been found to be consistently much higher as compared to the freshly applied phosphate. Rate of increase of phosphate uptake in the case of residual phosphate could be two to three-folds as compared to freshly applied phosphate depending upon the extent of build up of phosphate residues from past manuring.

(ii) Both phosphate uptake and exchangeable phosphate content of soils decrease progressively with the increasing period of cropping up to seventh cut. However, the rate of decrease is much faster initially. This is true for both freshly applied and residual phosphate. Correlation between phosphate upake and exchangeable soil phosphate has been found to be highly significant, the regression equation being $Y = 15.13 + 0.435\ X$, where Y = phosphate uptake in mg and X = Exchangeable phosphate content in p.p.m. Exchangeable phosphate measurement contributed 71 p.c. towards the phosphate uptake by the indicator crop. Although water- soluble soil phosphate fraction, in general follows the same decreasing trend as that of exchangeable phosphate with progressive cropping, the correlation between phosphate uptake and the water-soluble soil phosphate has not been found to be as good as between P uptake and exchangeable phosphate. The relationship between phosphate uptake in mg (Y) and water soluble soil phosphate fraction in p. p. m. (X) is, however, significant and is described by the regression equation, $Y = 15.79 \times 2.36\ X$ Water soluble phosphate contributed only 37 p. c. towards the phosphate uptakes by the indicator crop.

(iii) The two soil phosphate parameters namely, exchangeable and water soluble phosphates, are correlated in a highly significant way between themselves, the regression equations being :

(a) $Y = 1.8111 + 0.141\ X$ ($r^2 = 0.84$, $P < 0.001$) .. ..for soils with freshly applied phosphate.

(b) $Y = -9.28 + 0.53\ X$ ($r^2 = 0.90$, $P < 0.001$) .. ..for soils with residual phosphate.

Where X = Exchangeable phosphate in p.p.m. and Y = water - soluble phosphate in p. p. m. However, under our high acid soil conditions, exchangeable phosphate appears to be a better index than water-soluble phosphate for purpose of prediction of phosphate uptake and, therefore, response (if any).

Changes in available soil phosphate

Another field experiment at Borbhetta (Experiment No. B. 23/3 of Agronomy Department) was followed at bi-monthly interval for a period of sixteen months to ascertain the changes in soil exchangeable phosphate content. The effects of the levels of phosphate manuring season, as well as the interaction of phosphate × season on the changes in exchangeable soil phosphate content have been found to be significant. With the increasing levels of phosphate application up to 200 kg P_2O_5/ha, exchangeable phosphate content of soil tends to increase curvilinearly, the regression equation being, $Y = 88 + 0.55 \times -0.009\ X^2$, where Y = soil exchangeable phosphate in p.p.m. and X = levels of application of phosphate. However, the rate of increasing in exchangeable soil phosphate per unit change in applied phosphate calculated from the curvilinear relationship indicates that beyond 300 kg P_2O_5/ha application level no more increase in soil exchangeable phosphate takes place.

As far as the seasonal effect of soil exchangeable phosphate is concerned, it has been observed that, irrespective of the levels of manuring, exchangeable phosphate remains lower during the dry period January to May than during the wet months July to November. In general, a declining trend in exchangeable phosphate has been noted from July to following March.

Changes in leaf phosphate

The same field experiment, as mentioned above, has also been followed up in order to find out the changes in phosphate content of "two and a bud" plucked shoots as a result of phosphate manuring. The effects of the levels of phosphate manuring, season and the interaction between season and phosphate on leaf phosphate concentration have been found to be highly significant. With the increasing levels of phosphate application up to 180kg P_2O_5/ha, leaf phosphate concentration increases curvilinearly, the regression equation being, $Y = 0.85217 + 0.000526\ X - 0.000001536\ X^2$, where Y = p. c. P_2O_5 in plucked shoot and X = levels of application of phosphate. From the curvilinear relationship, the percentage increase of plucked shoot phosphate content due to different levels of manuring have been calculated and these have been found to be 2.70, 4.30 and 5.28 percents at levels of P_2O_5 application 50, 100

and 150 kg/ha respectively. The theoretical maximum increase of leaf phosphate concentration is however, 5.40 p.c. at the level of application of 170 kg P_2O_5/ha, beyond which leaf phosphate tends to decline.

However, such a decline has not been noted with third leaf phosphate concentration. Phosphate concentration in the third leaf increases linearly with increasing levels of applied phosphate, regression equation being Y 0.7158 + 0.000296 X, where Y p. c. P_2O_5 content in the third leaf and X levels of applied phosphate. Levels of applied phosphate contributed 96 p.c. towards the p. c. phosphate content in the third leaf. Percentage increase of third leaf phosphate content have been found to be 2.07, 4.14, 6.20 and 8.27 at levels of manuring 50, 100, 150 and 200 kg P_2O_5/ha respectively.

As far as the seasonal effects on leaf phosphate are concerned, both plucked shoot (two and a bud) and third leaf follow the same trend, i.e., leaf phosphate tend to decline from March to July followed up by a steady increase from July to November. The increase of leaf phosphate is in agreement with the decline in soil exchangeable phosphate between July and November.

Studies on soil nitrogen

Nitrogen balance sheet study (see Ann. Sci. Report, 1974-75, P. 24) has been repeated with urea as the source of nitrogen, the levels of application of nitrogen being 0, 100 and 200 kg per hectare in single and five equal splits. Natural rainfall has been simulated for purpose of leaching, applying 7.5, 20.0, 27.5, 32.5 and 37.5 cm rain in March, April, May, June and July respectively. Besides gaseous loss has been monitored from time to time by a specially designed system incorporated into one pot each under nitrogen levels 0, 100 and 200 kg/ha both under the forms urea and S.O.A.

Results so far indicate that the gaseous loss, although insignificant, has been almost double in the case of urea as compared to that of S.O.A. irrespective of the levels of application, i.e., either 100 or 200 kg N/ha.

As far as the leaching losses are concerned, it appears that the peak losses take place one month after application of urea irrespective of the levels of application and the quantities of rainfall. The time lag could be due to the completion of nitrification process. However, the total quantities of loss increases with increasing levels of application of nitrogenous fertiliser and most loss of applied nitrogen takes place in the nitrate form. Loss of ammonical nitrogen through leaching has been found to be insignificant. The cumulative nitrate nitrogen leaching loss—time relationships show that the rates of leaching losses are faster initially for a period of one month following a linear trend and thereafter rates progressively slow down following a curvilinear pattern.

Studies on soil Zinc

A suitable method of extraction of available zinc in acid tea soils has been standardised from the following points of view: (a) interfering ions, (b) pH dependence, (c) soil: extractant ratio, (d) quantity of soil for analysis, (e) equilibration time for extraction, (f) efficiency of different extractant and (g) recovery of added zinc.

Some of the interesting points observed are as follows: (i) method utilising Zn dithiozone colour reaction can be much simplified because of the non-interference of Cu, Pb, and Cd in our acid tea soils; (ii) increasing the ratio between soil and the extractant increases available zinc up to a certain limit, i.e., soil : extractant as 1:10; (iii) increasing the weight of soil does not have any perceptible effect on the extraction of available zinc; (iv) available zinc increases progressively with increasing equilibration time up to 45 minutes beyond which no further increase takes place; (v) successive 45 minutes extractions show that all of the available zinc get displaced during the first extraction and there has been no further release from the reserve to the available pool with further extractions; (vi) the efficiency of extraction of available zinc has been found to be practically same for all the three extractants namely, a two-phase system of neutral normal ammonium acetate and carbon tetrachloride containing dithiozone, 0.1 (N) Hcl and 0.2 p.c. EDTA; (vii) the recovery of added zinc has been found to be fairly satisfactory (92—95 p.c.) by any of the three methods cited above.

For convenience sake modified ammonium-acetate-dithiozone extraction method has been accepted (using 2.5 g soil, 1:10 soil : extraction ratio and 45 minutes equilibration time) for determination of available zinc in acid tea soils. A reconnaisance survey of the old alluvium soils under tea in Assam shows that available zinc values vary between 10 100 p.p.m., whereas total zinc content of these soils could be between 200-400 p.p.m. levels. This survey indicates that about 20 percent of the total zinc present in old alluvium soils can be potentially available for tea. Further fractionation of soil zinc shows that water-soluble fraction comprises 0.5 to 1.0 p.p.m., i.e., roughly only 0.1 -0.2p.c. of the total, dilute acid-soluble fraction comprises 6 -7 p.c. of the total whereas the exchangeable fraction

comprises most of the available zinc in our soils, i.e., 13-14 p.c. of the total.

It has also been observed that available zinc content is positively correlated with organic matter contents of old alluvium soils, the regression equation being Y= 14.50 + 32.39 X, where Y=p.p.m. available zinc content, and X = p. c. organic matter content. Soil organic matter content contributed 60 p.c. towards availability of zinc content of old alluvium soils. There are indications that the finer fraction of our soils, i.e., silt plus clay content, can also have positive influence on the availability of zinc, confirmation of which is now being sought including large number of soils from various regions.

As far as the zinc content in tea leaf is concerned, it has been found that wet ashing (i.e., digesting with tri-acid mixture) is better than the dry ashing from the point of view of recovery. Leaf analysis carried out so far indicates clonal differences, age (of leaf) difference, as well as typical distribution pattern of zinc according to leaf position on both sides of the stem. Further studies on leaf zinc are in progress on the different aspects mentioned above.

Diagnostic aid for fertiliser recommendation

Soils from all the NPK experiments laid out in different agro-climatic regions of North East India have been analysed for N, P and K and the data are now being processed for carrying out soil test-crop correlation studies in computer.

Soil Survey of Goalpara Tea District

In this survey eight tea estates, each with four profile sites representing North, South, East and West, were included. Soils were collected down to a depth of 90 cm at every 30 cm interval and were analysed for various physical and chemical characteristics. The following general conclusions can be drawn on the basis of the survey results :

(a) The soil profiles are by and large of silty loam type down to 90 cm, i.e., the effective root depth;

(b) Soils are of low permeability, specially in the sub-soil layers, generally varying between 0.20 to 0.50 m/day — their moisture capacity has also been found to be high;

(c) The soils are of highly acidic nature, pH ranging between 4.23 to 5.37, base exchange capacity varying beweten 4 to 19 m.e./100 g soil and percentage base saturation lying within 1 to 13 percent;

(d) The available potash, phosphate and zinc contents of soil generally vary within the ranges 10—60 p.p.m., 5—20 p.p.m. and 10—100 p.p.m. respectively. Further, both available potash and zinc contents tend to decrease with depth in majority of the profiles examined.

(e) Nitrogen and organic matter contents of these soils decrease with depth. Nitrogen and organic matter contents are, however, positively correlated at all depths. The relationships for the different depth of the soil profiles are as follows :

(i) $Y=0.0582 + 0.0525X$ ($r^2=0.59$, $P < 0.001$)... for 0—30 cm depth

(ii) $Y=0.0207 + 0.0759X$ ($r^2=0.55$, $P < 0.001$) .. for 30—60 cm depth

(iii) $Y=0.0267 + 0.0660x$ ($r^2=0.77$, $P < 0.001$ ... for 60—90 cm depth

where Y=percentage total nitrogen content of soils and

X= percentage organic carbon content of soils.

From the slopes of the above regression lines, it has been found out that total nitrogen content in the top and sub-soil layers of the profiles comprise 5 and 7 p.c. respectively of their organic matter counterparts, i.e., one percent increase in organic matter content is likely to effect simultaneously an increase of 0.05 and 0.07 p.c. nitrogen in top and sub-soils respectively.

Effect of phosphate manuring on feeder root production

The influence of phosphate manuring on the production of absorbing roots was followed for one full year at bi-monthly interval in experiment No. B.23/3 of the Agronomy Department. For this purpose, only those plots which received phosphate at 0, 100 and 200 kg P_2O_5 /ha were included.

Combined statistical analysis of all the seasons as well as individual seasonal analysis show that feeder root production decreases significantly with high levels of phosphate manuring. The interaction of phosphate and the season on root production has also been found to be highly significant. However, as far as the negative influence of phosphate on the feeder root production is con-

cerned, there has not been any significant difference between application rates of 100 and 200 kg P_2O_5/ha. The causal explanation for the observed negative effect of phosphate (source being triple superphosphate) on feeder roots is now being searched by following up the changes in soil and root characteristics, as well as by laying out pot trial under glass-house conditions.

Soil moisture use under different spacings

The changes in soil moisture content down to 90 cm depth under spacings 120 × 90 × 60 cm, 120 × 60 × × 60 × 60 cm, 50 × 50 cm and 30 × 30 cm were further followed up weekly during 1975-76 dry period at Meleng Tea Estate. Total moisture was estimated at 30 cm interval down to 90 cm and available moisture was monitored by installing gypsum blocks again at 30 cm interval down to 90 cm. Four replicate blocks were chosen under each spacing for purpose of measurement of both total and available soil moisture.

The results on the changes of total soil moisture content confirm our earlier finding that upto a plant population of 33,000 plants per hectare soil water utilisation during the dry period under mid-Assam conditions does not alter significantly. Beyond this critical limit the soil water usage, however, increases in a highly significant way. Further, it has been observed that beyond the critical limit, depletion of soil moisture almost equally takes place in all the three layers (i.e., 0 -30, 30 - 60 and 60—90 cm) examined. However, under spacings 120 × 90 × 60 cm, 120 × 60 × 60 × 60 cm and 50 × 50 cm, soil moisture depletes down to 60 cm only contrary to spacing 30 × 30 cm, where a significant depletion has been noted down to 90 cm depth. This confirms our previous finding that under very close spacing beyond the critical limit, exploitation of sub-soil water becomes more efficient by virtue of the increased vertical distribution of roots (including absorbing ones).

Measurements of available soil moisture have been found to be erratic and no correlation could be established between the total and the available soil moisture contents during the dry period, irrespective of the depths or spacings included in this study.

Studies on water table

As reported last year, tea bushes grown with water table fixed at 90 cm from the surface yielded significantly much higher crop than those having water table at 135 cm throughout 1975 cropping season. Weekly soil moisture monitoring during the dry period (December to May) has shown that the top 30 cm layer of soil in tanks with 90 cm water table contained about 2.5 cm more water than those having water table at 135 cm. However, besides the observed difference in top soil moisture content, there coud be other reasons for the relative difference in yield between the tanks with water tables at 90 cm and 135 cm respectively from the surface.

Monthly soil and plucked shoot analyses did not reveal any significant difference in nitrogen, phosphate and potash contents of either harvest or soils between the tanks with 90 and 135 cm water tables respectively. However in line with the yield trends, the total uptake of N, P and K from the tanks with 90 cm water table have been found to be much higher than those having water table at 135 cm from the surface.

Soil Rehabilitation and Mulching

Permanent grass plots under tall (Guatemala) and short (Citronella) grasses were made use of for measurements of various physical and chemical characteristics of soils with the intention of finding out the changes in these soil factors due to root growth under short and long-term grass cover. Aggregate sizes, bulk density, moisture equivalent, permeability, organic matter content and total root weight were measured. The data are now being processed to find out the correlations between total root weight and the various soil factors measured.

The physico-chemical changes of soil in rehabilitation micro plots at Borbhetta have also been followed up biennially including all the soil parameters as mentioned above. The experiment provides a comparison between the cover crops namely, guatemala, hybrid napier, citronella and mimosa as well as between simple mulching and the different cover crops. The experiment will continue for one more year to have the full effects of various rehabilitation treatments on the soil physico-chemical properties.

In order to find out whether heavy soils necessitate periodic cultivation either in the form of deep or fork hoeing, a coordinated trial between Soils and Agronomy has been laid out in Upper Assam, where the influence of various cultivation methods employed is measured on soil physical properties like bulk density, aggregate status and moisture holding capacity. The ultimate aim is to correlate the changes in the above physical parameters, if any, with crop yield.

Run-off Studies

Analysis of high, medium and low intensity storms and run-off shows that both medium (2.50 — 3.75 cm/hr)

and high (4.00—7.25 cm/hr) intensity storms maintain a better correlation with run-off rather than low intensity rains. Futher, duration of the medium and high intensity rains influences the total run-off. Under medium intensity storm (common in mid- Assam), the total run-off increases linearly with progressive increase in the duration of such storms. The total run-off from medium intensity storms in 6 p. c. slope has been found to be consistently higher than that of 1 p. c. slope while no appreciable difference between 1, 2 and 3% slopes were observed.

Leaf Analysis

Preliminary studies on leaf analysis indicate:

(a) **Diurnal changes in leaf nutrient content**— N, P and Ca tend to increase from morning (8 a. m.) to mid-day (12 O'clock), whereas K decreases and Mg remains unaltered, the trend of changes has been found to be similar for bud, 1st to 6th leaf, as well as petiole, lamina and internode; the changes in concentration of nutrients have been found to be maximum in the case of internode and minimum in petiole;

(b) **Physiological changes in leaf nutrient contents** N, P and K progeressively decreases from bud to the sixth leaf through 1st, 2nd, 3rd, 4th and 5th leaves; Calcium follows a reverse trend, i.e., Ca increases from bud to the sixth leaf, whereas Mg remains unchanged; these trends have been similar for either lamina or whole leaf;

(c) **Clonal differences in leaf nutrient content** TV7 (Chinary), in general, shows higher concentrations of N & P (anions) and lower concentrations of Ca, Mg and K (cations) than TV20 (Assam), which is in agreement with their root cation exchange capacities (C. E. C.) governing selective uptake; the cation/anion ratio for both the clones TV7 and TV20 has, however, been found to be constant, e. g., cation/anion ratio of TV7 equals 1.2 ± 0.2 m.e./100 g and of TV20 equals 1.3 ± 0.3 m. e/100 g thereby indicating a balance in the uptake of anions and cations by tea.

Research and Advisory soil analysis

About 61,000 soil tests were carried out during the year. The break-up as follows:

(i) **Research :** For Soil's Department as well as for other Department 16,500 estimations.

(ii) **Advisory :** (a) **Tocklai Unit: 43,000** estimations.
(b) **Dooars Unit:** 1,656 estimations.

General

(i) Mr. N. Barpujari a C. S. I. R. Junior Research Fellow, has joined the Department in November '75. He will be working on the application foliar diagnostic methods in mineral nutrition of tea.

(ii) Mr. D. Saikia, a M. Sc. (Tea Science) student of the Assam Agricultural University, has joined in March'76. He will be working on the influence of soil moisture regimes on the uptake of potassium and thereby growth of tea plants.

(iii) Mr. N. G. Bhattacharyya and Mr. A. K. Sengupta have taken over charges of Tocklai and Dooars Soil Testing laboratories respectively as Assistant Soil Scientist.

Plant Improvement

1. Release of biclonal stock

One more biclonal stock, 397, was selected for release during the year.

Stock 397 is a hybrid stock resulting from the cross between the well known Tocklai clone 19. 29. 13 (TV 1) and a dark-leaf Assam clone 19.35.2 of above average yield and quality. The stock is fairly uniform in its growth habit and leaf size. It is suitable for both C.T.C. and Orthodox manufacture.

The yield and quality of the stock has been found to be better than the popular commercial jats and similar to Tocklai biclonal stock 449. The stock is expected to do well in dry areas of Assam, Dooars, Terai and Cachar.

2. Production of clonal seed

Seeds of five biclonal stocks from the micro-baris were distributed in different agro-climatic regions for establishing observation plots. The clonal combination of one of the micro-bari was found to be incompatible and was converted into a new combination by grafting. One more micro-bari was established with a new biclonal combination.

On the basis of pollination results and short-time trial, a few biclonal combinations were selected for planting out of micro-seed baris for production of seed under natural condition.

Observations on yield performance and cup characters of the biclonal stocks under long-term trial (Ann. Rep. 1972-73, P. 45) indicate five of the stocks to be promising.

Nanda Devi Seed barie under producation at Borbhetta.

3. Pollination programme

The pollination programme for screening of combiner clones were continued. More than 2200 pollinations were done with 20 known combiner clones as female parent and using bulked pollen from a large number of clones. The objective of using bulked pollen was to create maximum possible variability in the offspring for selection of superior clones from the segregates. Seed -set was observed to be satisfactory in most of the crosses.

From the inter-specific crosses made earlier, (Ann. Rep. 1974-75, p. 31) a few seedlings were obtained from the crosses with *C. japonica* and *C. kissi*. Initial observations on their morphology reveals dominance of the non-tea species in characters like growth habit and leaf type. Further investigations will be carried out on their usefulness in breeding of tea and tracing the evolution and relationship of *Camellia* group.

4. Production of triploids

The seedlings obtained from crosses between high vigour tetraploids and high quality diploid clones (Ann. Rep. 1972-73, p. 45; 1974-75, p. 42) were examined cytologically. All the seedlings were found to be triploids with $2n=45$ chromosomes. The seedlings showed high vigour in comparision to normal seed varieties. After preliminary selection for desired characters, the bushes will be propogated for establishing small-scale trial for evaluation of cup characters and yield potentiality.

A few more pollinations were done on the tetraploids using a few more quality diploid clones as male parent.

5. Selection of vegetative clones

Selection work was carried out in a few old sections of hybrid tea in a neighbouring estate. Forty two bushes were selected initially and tasted for cup characters during the season. On the basis of yield records and quality, 14 bushes were selected for rooting and long-term trial..

From another selection trial (Ann. Rep. 1974-75, p. 32) 15 bushes were selected for rooting and long-term trial.

Rooting trial was completed for a total of 46 mother bushes selected earlier from different hybrid jats. On the basis of rooting success and nursery vigour, 16 clones were selected for long-term trial, which will be planedt out in spring 1976.

Newly released clone TV 21

Newly released clone TV 22

Newly released clone TV 23

6. Long-term trial of clones

One more long-term tril awas planted during the year. The total includes ten clones of both yield and quality series.

Six long-term trials with more than 100 clones are at various stages of selection. Three of the trials completed the first phase of one pruning cycle, out of which four clones were found to be outstanding in cup-characters and yield. These trials will be continued for another pruning cycle for final selection of the clones.

From the other long-term trials, six clones appear to be promising.

7. Selection of clones in tea estates

Under clonal selection scheme in the estates and to preserve tea germplasm, initial survey and work on mother bush selection was carried out in different regions. The area covered and the number of bushes selected are as follows :

	No. of estates	Area surveyed	No. of bushes selected
1. Darjeeling District	8	204.17 ha	177
2. Assam North Bank	5	185.56 ha	200
3. Assam South Bank	3	71.33 ha.	131
Total	16	461.06	508

Although the response from the member estates were overwhelming, due to shortage of trained staff, the programme had to be phased out. It is expected to intensify the work from the next season.

Plant Physiology

8. Fundamental investigation on dormancy

In continuation of the growth room experiments on the influence of temperature on growth and dormancy in tea reported earlier (Ann. Rep. 1974-75, p. 34), the set of plants which were subjected to high temperature and humidity during 1974-75 cold weather, were kept at a low temperature of 5°C (±2°) during the summer months. The plants were found to remain dormant during the entire season, inspite of the longer day-length period.

Continuing the experiment, the same set of plants were again subjected to a higher temperature of 27°C (±2°) during the short-day winter months. Bud-break was noticed in the plants within two weeks and the plants

produced two flushes of growth between November and January. However, the shoots from both the flushes were found to be smaller, consisting of 1 to 2 leaves only. Initiation of a third flush was also noticed in the plants towards end January.

This interesting observations indicate possible interaction between day-length and temperature on control of hormonal balance in the plant and requires further investigation for fuller understanding of the growth and dormancy mechanism in tea plant.

Results of the bioassay of the growth regulating substances in the growing and banjhi buds during different seasons were also briefly reported in Ann. Scientific Report, 1974-75, p. 34. Further studies were made to find out whether the old leaves are the probable source of growth retarding substances and to find out the difference in the level of endogenous growth regulators between heavily shaded and unshaded old leaves. Results of the bioassay suggest old leaf to be a site of production of growth inhibitors. The level of growth inhibitors was higher in shaded old leaves than the unshaded ones, but the level of growth promoters though not statistically significant, showed a reverse tendency. Whereas the level of growth promoters was higher and that of growth inhibitors was much lower in growing buds of early growth in Jan /Feb. obtained by early pruning and complete defoliation of leaves remaining on the bush frame. These investigations suggest that growth inhibitors are synthesised in the old leaves during winter months and translocated to the shoot apices, thereby restricting new growth.

9. Field investigation on dormancy

In order to study the effect of different growth retardants and growth promoting substances on flushing behaviour and crop-pattern in tea, a few experiments were initiated during the year. Foliar spray of different concentration of growth retardants like 'Alar' (SADH), 'Cycocel' (CCC), Ethephon (CEPA) and growth promoters like Gibberellic acid (GA_3), Benzyl adenine (BA) was given on three different clones. Influence of these treatments on bud-break, shoot production, quality and residual effect on subsequent crop production are under observation. Initial results indicate differential behaviour of the chemicals in their action. Further work is in progress.

10. Pruning and plucking

Dry matter content

Results obtained from a preliminary investigation on the rate of dry matter production or precisely accumulation of dry matter per unit leaf area were found encouraging (reported briefly in Ann. Scientific Report, 1974-75, p. 34). An experiment was therefore started in June 1975 to verify the validity of the result under field conditions.

Four released clones, TV 3, TV 9, TV 11 and TV 16 from New Botanical Area were available for the investigation. Leaf discs of 0.5 cm^2 each and varying in number from 28 to 60, according to availability, were collected from 1st and 2nd leaf at 7 a. m. and 11 a. m. (IST) from a row of 8 bushes each. Samples were collected from June to November on each date of plucking initially on a 9 day round upto 16th July and then on a 7 day round upto the end of plucking on 26th November. The percentage increase of dry matter accumulation in 1st and 2nd leaf of different clones is shown in Table 1.

It can be seen from the table that the increment of dry matter varies from clone to clone, month to month and even between 1st and 2nd leaf. In spite of these variations the increment of dry matter of both the 1st and 2nd leaf at 11 a.m. over 7 a. m. is quite substantial in all the four clones and that too in every month. The dry weight of 1st and 2nd leaf taken together contributes about 50 per cent of the dry weight of plucked shoots i.e., total crop (Ann. Scientific Report, 1957, p. 70). Therefore, the rate of dry matter accumulation of these two major components of a plucked shoot will have a definite influence on the rate of yield increment. The data suggest that there is an optimum time of plucking during the day for having maximum dry matter of plucked shoots i.e., made tea. Some more investigations are necessary to determine that optimum time.

Fresh and dry weight of plucked shoots from the same bushes at 8 a. m. and 1 p. m. and the dry weights of the different shoot components were also estimated. The number of growing and banjhi shoots were counted on each occasion. From these data it will be possible to find out the diurnal and seasonal variation of dry weight of plucked shoots and the contribution of the different components of shoots and their influence on yield and quality of made teas.

From a survey of the data collected it is seen that dry weight per shoot decreases steadily from the beginning of the plucking season while the number of shoots per bush increases. Yield being the product of these two is

Table 1. Percentage increase of dry matter accumulation at 11 a. m. over 7 a.m.

Clone	Month	No. of observation	Mean dry wt. of 1st leaf in grammes per 100 Cm^2 leaf area		% increase at 11 a. m. over 7 a.m.	Mean dry wt. of 2nd leaf in grams per 100 Cm^2 leaf area		% increase at 11 a. m. over 7 a.m.	Mean % increase of 1st + 2nd leaf
			7 a. m.	11 a. m.		7 a. m.	11 a. m.		
TV 3	June	3	0.53	0.59	11.32	0.53	0.60	13.21	12.27
	July	4	0.56	0.64	14.29	0.59	0.64	8.47	11.38
	August	4	0.56	0.61	8.93	0.57	0.61	7.02	7.98
	September	3	0.52	0.58	11.54	0.52	0.60	15.38	13.46
	October	4	0.49	0.57	16.33	0.49	0.56	14.29	15.31
	November	4	0.47	0.54	14.89	0.48	0.53	10.42	12.66
	Total	22	3.13	3.53	77.30	3.18	3.54	68 79	73.06
	Mean	—	0.52	0.59	12.88	0.53	0.59	11.47	12.18
TV 9	June	3	0.54	0.60	11.11	0.54	0.60	11.11	11.11
	July	4	0.57	0.62	8.77	0.58	0.64	10.34	9.56
	August	4	0.55	0.60	9.09	0.56	0.62	10.71	9.90
	Septembr	3	0.52	0.58	11.54	0.51	0.59	15.69	13.62
	October	4	0.47	0.56	19.15	0.49	0.56	14.29	16.72
	November	4	0.46	0.55	19.57	0.49	0.53	8.16	13.87
	Total	22	3.11	3.51	79.23	3.17	3.54	70.30	74.78
	Mean	—	0.52	0.59	13.21	0.53	0.59	11.72	12.46
TV 11	June	3	0.58	0.62	6.90	0.57	0.61	7.02	6.96
	July	1	0.60	0.62	3.33	0.61	0.63	3.28	3.31
	August	4	0.58	0.62	6.90	0.59	0.62	5.08	5.99
	September	3	0.53	0.58	9.43	0.52	0.59	13.46	11.45
	October	1	0.50	0.52	4.00	0.49	0.55	12.24	8.12
	November	4	0.51	0.53	3.92	0.50	0.54	8.00	5.96
	Total	22	3.30	3.49	34.48	3.28	3.54	49.08	41.79
	Mean	—	0.55	0.58	5.75	0.55	0.59	8.18	6.96
TV 16	June	3	0.57	0.61	7.02	0.58	0.62	6.90	6.96
	July	4	0.55	0.61	10.91	0.61	0.64	4.92	7.92
	August	4	0.55	0.61	10.91	0.58	0.61	5.17	8.04
	September	3	0.50	0.57	14.00	0.52	0.57	9.62	11.81
	October	4	0.48	0.54	12.50	0.49	0.53	8.16	10.33
	November	4	0.47	0.52	10.64	0.49	0.54	10.20	10.42
	Total	22	3.12	3.46	65.98	3.27	3.51	44.97	55.48
	Mean	—	0.52	0.58	11.00	0.54	0.58	7.50	9.25

affected largely through increase in shoot number which confirms our earlier finding. All these data are awaiting statistical analysis.

11. General

(a) Mr. B. N. Gogoi, Asst. Plant Physiologist was deputed for a three months training course on the use of radio-isotopes in agriculture at IARI.

(b) Dr. L. Manivel, Asst. Plant Physiologist joined in January 1976. He is expected to work on NPK nutrition, photosynthesis and dormancy in tea plants.

(c) Mr. T. C. Chaudhuri joined as a Junior Research Fellow in Cytogenetics in Januray 1976. He will be working on Cytogenetic of aneuploid and polyploid tea and their breeding behaviour.

(d) Mr. K. N. Dutta, Asst. Plant Breeder, proceeded on preparatory leave in January prior to retirement.

(e) Mr. S. C. Gogoi, Field Asst. proceeded on preparatory leave in January prior to retirement.

Biology of Mites

Clonal susceptibility to mites

Susceptibility of Tocklai clones TV 11 to TV 15 to scarlet mite, *Brevipalpus phoenicis* (Geijskes), was assessed under laboratory conditions from the fecundity of the mite on these clones. At 32°C and 77% RH maximum eggs (average : 20 per female) were laid on clone TV 13 followed by clone TV 14 (average eggs per female: 16) under comparable conditions minimal eggs (5 per female) were laid on TV 11. Insipite of this variation, a significant was not found in the duration of incubation period and life-cycle of the mite on these clones, which were 5—6 days and 19 — 20 days respectively (table 1).

Table 1. Fecundity, incubation period and life-cycle of *Brevipalpus phoenicis* (Geijskes) at 31—32°C and 77% RH.

Clone No.	Incubation Period (Days)	Average Duration of life-cycle (Days)	Average number of eggs laid per female
TV 11	6	19.2	5.0
TV 12	6	19.0	10.0
TV 13	6	20.3	20.2
TV 14	5—6	19.0	15.7
TV 15	5—6	19.8	11.8

Life-cycle and fecundity of scarlet mite on clones TV 1 to TV 5 at 25°, 30° and 32°C were also studied. Duration of the immature stages, and life-cycle in general, did not vary at a particular temperature on different clones. On each clone the life-cycle was completed on an average in 29, 24 and 20 days at 25°, 30° and 32°C respectively. An inverse relationship exists between duration of the life cycle and temperature. Fecundity was high on clones TV 1, TV 3 and TV 5 and least on clones TV 2 and TV 4 at all temperatures.

Shifting of the host plants i.e., inter-changeability of the clones (from TV 6—15 to TV 8) during any phase of the development of the mite did not significantly alter the course and duration of the development.

At 15°C and 77% RH scarlet mites did not lay any eggs on any of the clones TV 6 — TV 10. Even if they were kept at 25°C for 2 hours, and then switched on to 15°C for 22 hours, no oviposition occurred. If exposed to 6 hours at 25°C, and 18 hours at 15°C only a few eggs were laid, and lesser still if exposed at 25°C for 4 hours.

Preference of red spider to tea leaves of different ages

A study was made in the laboratory to find out the preference of red spider to the order of emergence of the leaves. Five freshly emerged adult female mites were placed on 1st, 2nd, 3rd, 4th and 5th leaves of both Assam and China types of tea. Each set had three replications. The results (table 2) shows that in both Assam and China types of tea, 4th and 5th leaves are most preferred hosts. More eggs, and in effect, more red spider populations persist on these leaves. This preliminary study suggests that older leaves may provide more stimuli for rapid build up of mite population than the relatively younger leaves.

Table 2. Red spider infestations on tea leaves of different ages.

Tea variety	Treatments	Fecundity and population of red-spider on 1st leaf	2nd leaf	3rd leaf	4th leaf	5th leaf
Assam variety	Average no. of eggs laid in 5 days	42	66	99	134	127
	Average no. of original adult females remained after 5 days	2	3	4	5	5
	Population of red spider after 9 days (excluding eggs)	38	61	93	130	123
China variety	Average no. of eggs laid in 5 days	37	44	77	119	110
	Average no. of original adult females remained after 5 day	1	1	4	6*	7*
	Population of red spider after 9 days (excluding eggs)	34	41	90	112	103

* Red spider migrated from 1st to 3rd leaves

Distribution, abundance and succession of mites in relation to field Management practices

(a) **Red spider population in relation to longer pruning cycle**

Population cycle of the mite was studied on tea bushes under different pruning cycles. The first series of the treatment included top prune, light skiff and unprune, and the second light prune, medium skiff and unprune. Throughout the season in both the series incidence of red spider was minimum on light pruned tea, and maximum on unpruned tea. These observations suggest that red spider incidence varies directly with the quantity of foliage left on the bushes following pruning operations.

(b) **Clonal susceptibility to mites under field conditions**

(i) Incidence of red spider on clones TV 1—TV 19 all under similar field management practices was assessed. Mite population was maximum on TV 1, followed by clones TV 7 and TV 18. Population was least throughout the season on clones TV 4, TV 5, TV6 and TV 19: remaining clones occupied intermediate position.

(ii) Susceptibility of scarlet mite to clones TV 1 to TV 11 indicates the mite population was highest on clones TV 8 and TV 11, but least on clones TV 2, TV 6 and TV9. It appears that the susceptibility of clones to scarlet mite is dependent on the fecundity of mites as already reported in case of laboratory studies. Responses of these two species of mites to bushes under identical condition thus varies, reflecting in each case the specific innate food requirements of the species.

Effect of spraying zinc on the incidence of mites

Studies were initiated on the incidence of different species of mites on tea treated with zinc sulphate @ 24 kg/ha in 4 rounds. Preliminary observations show that the populations of pink and pruple mites were appreciably on the higher side in the zinc treated plots. The incidence of red spider and scarlet mite was very low at the time of these observations. These observations are being continued.

Susceptibility of clones TV 9 and TV 18 to pink and purple mites

In Cachar field studies were made on the occurrence of pink and purple mites on two year old TV 9 and TV 18. Populations of both the mites were significantly higher on clone TV 18 than on clone TV 9. Reasons for this varied response are not clear as yet.

Biology of Insects

Cockchafer

Life-history of the cockchafer, *Sophrops plagiatula* (Brenske) attacking tea in the North Bank has been worked out (table 3).

Table 3. Duration of different stage of *Sophrops plagiatula*

Stages	Duration (in days)
Egg	10—12
First instar	31—35
Second ,,	114—118
Third ,,	142—147
Pupal	13—15
Life cycle	310—325

The larval stage remains inside the mud cell for 110-130 days: pupation begins in mid-March and the adults emerge in late March or early April. The Dooars species of cockchafer, *Phyllophaga seticollis* becomes adult October—November but remains inside the mud cell till late March/early April. A basic difference in the bionomics of the two species is that while the North Bank species hibernates in the larvel stage, in the Dooars species it is the adult that hibernates.

Incidence of cockchafer was recorded in plots of tea treated differentially with mulch, mulch plus three rounds of spray of Thiodan at 1 in 500 parts water in April, June and August, and without any mulch. Only 3.5% of the tea in mulched area was attacked by cockchafer, and 10% in unmulched area, but none in Mulch + Thiodan area.

Termites

1. Experiments have been laid out to find out the effect of weedicides and mulch as soil treatments on the activities and behaviour of termites. Results of these experiments will be available next winter.

2. Field studies in Cachar show that both the extent and intensity of termite attack on tea were significantly higher in cold patches than in hot ones. The percentage of bushes infested and intensity of attack was 64% and 1.21/bush respectively in cold patch compared to 30% and 0.58/bush in hot patches under comparable field conditions.

3. The susceptibility of clones TV 1, TV 9, TV 18, P 7 and P 126/A, all under similar field condition, in Cachar was evaluated. Termite attack was maximum on P 7 and P 126/A, followed closely by TV 9. Infestations on TV 1 and TV 18 were minimum at the end of the year.

Scale insect

Hemiberlesia latanae (Signoret) : Life-history of this species of scale has been worked out under laboratory conditions. The duration of the immature stages of the female is shown in table 4: males were not available.

Table 4. Duration (in days) of egg and immature stages of female *H. latanae*.

Stages	July	Sept/Oct.	Oct/Nov.	Nov/Dec/ Jan.	Feb/March
Egg stage	1—2	2—3	2—4	3—4	2—3
Total duration of immature stages	23—27	25—28	25—29	63—65	48—52

The fecundity rate of the scale varied in different seasons between 74 and 40.

Aspidiotus destructor (Signoret :) This scale occurs mostly on the lower surface of leaf particularly along the mid-rib and margin. Although it is a major pest of coconut, of late it has been damaging young tea.

The duration of different stages of female scale are given in table 5: males were not available.

Table 5. Duration (in days) of egg and immature stage of female *Aspidiotus destructor.*

Stages	Oct.'75	Nov.'75	Dec.'75	Feb./March'76
Egg stage	1 –2	2 –3	4—6	2 –3
Total duration of immature stages	26– 27	26– 30	–	31—35

Pinnaspis theae (Maskell) : A serious pest of tea in Darjeeling, this scale is now well established on young plants in the Dooars and Assam.

The duration of egg stage is 16—20 days and of immature stages 40 –42 days during winter. Biological studies are in progress.

Biology of Root-knot nematodes

(a) **New records of plant parasitic nematodes :** *Rotylenchulus* sp., *Radopholus* sp., *Hemicycliophora* sp. and *Tylenchulus* sp. have been recorded for the first time as parasitic nematodes in rhizosphere of both young and mature tea.

(b) New records of weed hosts of *Meloidogyne* spp.: The new hosts of *Meloidogyne incognita* and *M. javanica* in tea soils are:

1. *Agaratum conyzoides* Linn.
2. *Bonnaya bracheata* Link
3. *Oxalis corniculata* Linn.
4. *Peperomia pellucida* H B & K.
5. *Phyllanthus niruri* Linn.
6. *Pouzolzia indica* Gand.
7. *Spermacoce ocymoides* Burn.
8. *Polygonum perfoliatum* Linn.
9. *Solanum indicum* Linn.
10. *Drymaria cordata* Willd.

(c) **Root-knot nematode on tea stem :** *Meloidogyne incognita*, basically a root infesting nematode, has been observed to infest stem tissues of tea seedlings at the collar region. The degree of infestation was however mild.

(d) **Effect of Marigold on root knot population in the soil :** Marigold plant grown in replicated brick cubicles in the greenhouse for four months reduced the population but failed to give lasting control of root-knot nematode (*M. incognita*) in the soil. Tea seedlings grown in these cubicles after uprooting the marigold plants developed root-knot infestation in the roots (Table 6).

Table 6. Effect of Marigold on *Meloidogyne incognita* **population.**

Initial population/100 g soil	Population/100 g soil after		Marigold uprooted and tea seedling planted			
	1 month	3 months	after 5 months		after 7 months	
			Population /100 g g soil	Average gall/ plant	Population 100 g soil	Average gall/ plant
124	92	16	28	4	100	12

Apparently marigold suppresses root-knot population only temporarily : when a good host plant is planted in the same area, the residual population builds up appreciably.

Marigold is also conducive to build up of the population of *Rotylenchulus* sp. The possible pathogenic effects of the species of eelworm on tea seedlings are under study.

(e) **Growth response of clonal tea to nematode infestation :** TV 1 and TV 14 do not show any appreciable differences in their growth even after three months of continuous exposure to soil having monoculture of root - knots. These observations cannot be generalised at present, but the possibilities are there that as with mites, clones may respond differentially to root knot infestation at a later stage. Further observations are in progress.

(f) **Nematode survey :** Tea estates at different altitudes in Darjeeling were surveyed for the distribution and abundance of plant parasitic nematodes (table 7).

Table 7. Occurrence of the main plant parasitic nematodes in mature tea sections at different altitudes in Darjeeling.

Altitude (Metre)	Percentage of soil samples with-					
	Meloiogyne sp.	*Pratylenchus* sp.	*Helicotylenchus* sp.	*Paratylenchus* sp.	*Tylenchus* sp.	*Rotylenchulus* sp.
0 –750	22	24	90	20	90	2
750—1200	30	25	76	8	100	0
1200 –above	25	45	72	3	88	0

Meloidogyne spp. and *Tylenchus* sp. are most prevalent between 750 and 1200 metres; *Pratylenchus* sp. at 1200 m and above; *Helicotylenchus* sp. and *Paratylenchus* sp. at 750 m and below *Rotylenchulus* sp. is present only in a few samples 0—750 m. Some overlappings have also been noted.

The survey shows that *Meloidogyne* is more common in seed nursery than in clone nursery; the position of *Pratylenchus* sp. is just reverse.

Screening and evaluation of pesticides

Acaricides

Different acaricides were used at lower doses along with standard dose (1.25 l/ha) for the control of red spider.

In one series, Nuvacron, Zolone, Omite and Tedion each @ 1.25 l/ha and 0.5 l/ha were tried. Except Zolone, all other acaricides gave good control of red spider at both the doses; Zolone was effective only @ 1.25 l/ha (Table 8).

Table 8. Mortality responses of red spider to lower concentration of some acaricides.

Date of spraying -3.5.75
Equipment—Mist blower power sprayer

Treatments	Observation after 1 month	
	Mean population	% reduction over control
Nuvacron 40 E. C. @ 1.25 l/ha	0.00	100
Nuvacron 40 E. C. @ 0.5 l/ha	1.33	86
Zolone 35 E. C. @ 1.25 l/ha	0.67	93
Zolone 35 E. C. @ 0.5 l/ha	6.33	34
Omite 57 E @ 1.25 l/ha	1.33	86
Omite 57 E @ 0.5 l/ha	1.00	89
Tedion V—18 E. C. @ 1.25 l/ha	0.00	100
Tedion V—18 E. C. @ 0.5 l/ha	0.33	96
Control —	9.67	—
Mean C. D.	3.96	—

In a second series, a new formulation of Kelthane (Kelthane 55 E.C.), a new acaricide Cyanatox, and Nuvacron—each @ 1.25, 1.00 and 0.625 litre/ha were tried. Nuvacron even @ 0.625 l/ha gave 90% reduction in red spider population, but Kelthane 55 EC gave good control only at 1.25 l/ha. Cyanatox even at 1.25 kg/ha failed to control red spider (Table 9).

Table 9. Comparative efficacy of different doses of some acaricides against red spider.

Date of spraying — 11.12.75
Equipment—Mist blower power sprayer

Treatments	Observations after 1 month	
	Mean population	% reduction over control
Kelthane 55 E. C. @ 1.25 l/ha	16.67	97
Kelthane 55 E. C. @ 1.00 l/ha	167.33	74
Kelthane 55 E. C. @ 0.625 l/ha	251.67	60
Cyanatox @ 1.25 kg/ha	241.33	62
Cyanatox @ 1.00 kg/ha	430.00	32
Cyanatox @ 0.625 kg/ha	512.67	20
Nuvacron 40 E. C. @ 1.25 l/ha	15.00	98
Nuvacron 40 E. C. @ 1.00 l/ha	32.00	95
Nuvacron 40 E. C. @ 0.625 l/ha	63.33	90
Kelthane 18.5 E. C. @ 1.25 l/ha	141.67	78
Control-	637.67	- -
Mean C. D.	171.73	
C. V. %	44.20	

In another series Phendal (Cidial) @ 1.25 l/ha was as effective as Ethion @ 1.25 l/ha: reduction of red spider population over control varied between 90 and 95%.

Insecticides

Termites : Field trials were conducted in Cachar to control live wood eating termites, *Microcerotermes* sp. Dursban 200 E @ 10 l/ha and 15 l/ha, X-factor @ 10 l/ha and 15 l/ha, Nuvacron 40 E.C. @ 10 l/ha and Endosulphan 35 E. C. @10 l/ha were used. In a second series Thimet 10 G @ 100 kg/ha, Temik 10 G @ 100 kg/ha, Phosvel 34 E. C. @ 10 l/ha, Zolone 4% dust @ 25 kg/ha and Endosulphan 35 E. C. @ 10 l/ha were applied. These long term trials are in progress.

Cockchafer : Control trials were carried out against cockchafer grubs attacking young clonal tea in the Doo-ars. In one experiment X-factor @ 10 l/ha, Thimet 10 G @ 100 kg/ha, and Thiodan @ 10 l/ha and 5 l/ha have been tried. In another experiment X-factor @ 10 l/ha, Furadan 3 G @ 25 kg/ha, Duter 20 W. P. @ 3 kg/ha,and Thiodan 35 EC@10 l/ha and 5 l/ha were applied. Preliminary results show certain amount of variability: results of long term trials are awaited.

Flush worm : Nuvacron 40 E. C. @ 1.25 l/ha and 0.75 l/ha, Anthio also @ 1.25 l/ha and 0.75 l/ha, Ekalux at 1.25 l/ha and Dursban @ 3 l/ha were applied for the control of flushworm, *Lespeyresia leucostoma* (Meyer). One week after the insecticidal treatments, Dursban, Ekalux, and Nuvacron @ 1.25 l/ha gave 67% to 79% reduction of infested shoots over the control series having no insecticidal treatment. Four weeks after the treatment only Ekalux and Nuvacron gave good control of flushworm while Dursban was not effective: the reduction in affected shoots over control varied between 70 and 80%.

Nematicides

Prophylactic trials were conducted with Nemagon, DBCP, Temik, Dursban and Thimet for control of nematodes attacking tea seedlings. Results show that, except Dursban, all the nematicides were effective in reducing the nematode infestation. In one trial Nemagon gave the best result, while in another all the nematicidal treatments, except Dursban, were equitoxic.

Tainting effect

Tainting experiments were conducted with 28 formulations of different pesticides including Triton, Tispray, Starvit, X-factor, Ekalux, Nu-Flim, Kelthane, Elsan, Endosulfan, Malathion, Anthio, Ethion, Tetradifon, Acromax, Cyanatox and Ditaf. According to Tocklai Tea Taster only X-factor and Nu-Flim tainted the made tea one week after their applications.

Pesticide residue tolerance

Samples of manufactured and sun-dried tea treated with Omite 57 E and Dursban 20 E have been processed for residue analysis.

Pesticide Certification

Eight certificates of approval were issued to various formulations of plant protection chemical. Twenty certificates were revalidated after bioassay studies. Agreements were made for formal testing of 48 formulations of various pesticides.

Biological Control

The department collaborated with the Indian Station of the Commonwealth Institute of Biological Control in studying the natural enemy complex of the scale insects in the plains of Assam. Three parasitic wasps and two new species of predators were isolated from field populations of the common tea scale (*Fiorinia theae*).

MISCELLANEOUS

Visits : Training

Dr. B. Banerjee completed his World Bank IDA assignment as Visiting Professor in Agricultural Entomology and Adviser in Pest Management at the University of Nairobi and returned to Tocklai in August 1975. Mr. S. Mukherjee had a three months Advanced training in Acarology at the Agricultural University, Hebbal, Bangalore.

V. P. trainees and newly recruited Junior Scientific Assistants from Advisory Department were given refreshers course in pest control technology.

Advisory work

Pest infested materials from member estates were examined and remedial measures suggested. 2500 soil samples were analysed for eelworm populations. Bioassays were made for the samples of pesticides received from estates.

Mycology Department

Introduction

Mycology department is engaged in studies on control of tea diseases. The main thrust of the investigations is on the methods to reduce the quantity of traditional fungicides while still obtaining an effective control of the disease(s); and identification of new method/screening of new chemicals for economic control of tea diseases. Possibility of non-symbiotic nitrogen fixation has also been investigated. A new dimension has been added to the work of this department by including a new project on the effect of agricultural chemicals on soil microflora.

Biology and control of disease : Control of red rust, black rot, blister blight have been studied. A new bacterial disease reported last year has been studied.

Red Rust

Apart from one screening trial, field experimental work done during the year was mainly in elucidating the lower dosages of fungicides in controlling the disease using both power and hand operated sprayers. There were two series of trials.

A. The first series was to study the effect of application of lower concentration/dosages of a copper oxychloride formulation (Blitox) on diseased plants during actively sporulating period (May-July) of the alga. There were two trials—one with hand operated sprayer and the other with a power sprayer.

1. **Effect of concentration with hand sprayer :** This was laid out in a young tea area planted in 1970 with clone SD 1. The tea was left unpruned and was badly attacked by the disease during the first week of May. Shade and drainage were poor. Seven treatments including the unsprayed control were studied and were replicated 5 times. Each plot consisted of 23 bushes at 120 × 90 cm spacing. Under treatments 1 to 5, various dilutions ranging between 1:400 to 1:1000 in four rounds of spray was imposed, the first two at 14 day interval and the subsequent ones at monthly intervals. In the 6th treatment, six regular rounds of spraying at fortnightly interval were given. The first application was made on 6th May 1975 and the final on 15th July '75. All the plants in the experimental plots were thoroughly examined on the last week of April 1976 for the development of the algal fructification using the normal scale of 0 to 4. The results are presented in table 1.

Table 1. Effect of Blitox spray with hand sprayer at different concentrations on degree of incidence of the disease.

Treatments	Approx. quantity of Blitox used per round	No. of rounds	Mean degree of infection per bush	% reduction over control
1. Blitox 1:400	1.5 kg/ha	4	0.38	86.76
2. „ 1:600	1.0 „	4	0.31	89.20
3. „ 1:800	0.75 „	4	1.14	60.28
4. „ 1:1000	0.6 „	4	1.57	45.30
5. „ 1:1000 + *Pinolene	0.6 „	4	1.39	51.57
6. „ 1:1000	0.6 „	6	0.55	80.84
7. Unsprayed control			2.87	
C. D. at p 0.05			0.37	
C. V. %			24.7	

*Pinolene is a sticker spreader (extender) formulated by Miller chemicals and Fertilizer Corporation, Hanover, Penn. U.S.A. This was found to taint the tea.

Treatment Nos. 1, 2 and 6 were significantly superior to all other treatments while the difference between these three was not significant.

2. **Different dosages of concentration with Power sprayer**

A trial on similar line was conducted by using power sprayer. This was done on 8 year old, unpruned, poorly drained, almost unshaded, hedge planted (120 × 90 cm) tea, carrying moderately severe infection. Plots were of 20 bushes each and were replicated 4 times. Treatment No. 1 to 5 received various dilutions of chemical in 4 rounds and 6 rounds like in trial No. 1 were included in the 6th treatment. Treatments were applied between 19. 5. 75 and 25. 7. 75. The results are given in table 2 (Amount of water required for spraying a hectare was approximately 200 litres).

Table 2. Effect of Blitox spray with power sprayer at different dosages on degree of incidence of the disease.

Treatment & dosages	No. of rounds	Degree of infection per bush	% reduction over control
1. Blitox 2.5 kg/ha	4	0.53	69.54
2. ,, 1.25 ,,	4	0.71	59.20
3. ,, 1.0 ,,	4	0.78	55.18
4. ,, 0.625 ,,	4	1.00	42.53
5. ,, 0.625 ,, + Pinolene *	4	0.81	53.45
6. ,, 0.625	6	0.56	67.82
7. Unsprayed control		1.74	
C. D. at p = 0.05		0.38	
C. V.%		29.2	

Infection in this area was of lower order than in trial 1. Here also the beneficial effect of giving six rounds at fortnightly interval is evident.

B. Protective action of chemical : The other series was to study the protective action of lower dosage/concentration of the fungicide (Blitox) on new growth, in an otherwise heavily red rust affected area, wherefrom diseased branches were removed in the cold weather by heavy pruning. Six treatments (including the unsprayed control) were applied between 9.5. 75 to 16.7.75. Treatments No. 1 to 5 received various concentration/dosages in 4 rounds, 2 at fortnightly and 2 more at monthly intervals. Treatment 5 was applied at 14 day interval and altogether 6 rounds were given. They were replicated 4 times and each replicate had 25 bushes.

Two such experiments were conducted—one with hand operated sprayer and the other with power sprayer. All the plants were critically examined for degree of red rust infection during the 1st week of May 1976. The results are given in Table 3 (Hand sprayer) and table 4 (Power sprayer).

Table 3. Mean degree of red rust infection per bush as influenced by Blitox applied at different concentration in the preceding season (1975) with Hand operated sprayer.

Treatment & Concentration	Approx. quantity of Blitox required per round	No. of rounds	Mean degree of infection per bush	%reuduction over control
1. Blitox 1:400	1.5 kg/ha	4	0.29	87.66
2. ,, 1:600	1.0 ,,	4	0.54	77.02
3. ,, 1:800	0.75 ,,	4	0.90	61.70
4. ,, 1:1000	0.6 ,,	4	0.83	64.68
5. ,, 1:1000	0.6 ,,	6	0.27	88.51
6. Unsprayed Control			2.35	
C. D. at p 0.05			0.31	
CV %			23.75	

I is seen that 1:1000 applied in 6 rounds at 14 day interval is as efficient as 1:400 applied in 4 rounds, but 1:1000 when applied in 4 rounds it failed significantly.

Table 4. Mean degree of infection per bush as influenced by Blitox applied at different dosages in the preceding season (1975) with power sprayer.

Treatment & dosages	No. of rounds	Degree of infection per bush	% reduction over control
1. Blitox 2.5 kg/ha	4	0.20	91.03
2. ,, 1.875 ,,	4	0.33	85.20
3. ,, 1.25 ,,	4	0.36	83.86
4. ,, 0.625 ,,	4	0.81	63.68
5. ,, 0.625 ,,	6	0.48	78.48
6. Unsprayed control		2.23	
C. D. at P 0.05		0.22	
CV %		19.6	

Here also it is apparent that lower dilutions when applied in a strict 14 day schedule affords good protection.

Fungicide screening trial : Difolatan, Bangcop, Calixin, Bavistin, Copper oxychloride (TATA), Miltox and Blitox were tested for their efficacy in controlling the disease. Blitox was used as standard fungicide treatment. The treatments were applied with hand sprayers in 4 rounds (2 fortnightly and 2 monthly) in a 6 year old hedge planted (120 × 90 cm) young tea area bearing severe infection during the last week of May 1975. Spraying was completed between 6th May and 15th July 1975. Each plot consisted of 31 bushes. Each treatment was replicated 4 times. The overall effect of the treatments was estimated by critically examining each individual bush for degree of red rust infection in the following season (end of April 1976). The results are given in table 5.

Table 5. Degree of red rust infection per bush as influenced by different chemicals at various spray concentrations as against the untreated controls.

Treatments & rates	Chemical concentration rate/ha	No. of rounds	Degree of infection per bush	% reduction over control
1. Difolatan 1:700	870 g/ha	4	1.76	43.77
2. Bangcop 1:400	1.5 kg/ha	1	1.35	56.87
3. Calixin 1:1000	0.6 l/ha	4	2.90	7.35
4. Bavistin 1:1000	0.6 kg/ha	4	2.84	9.27
5. Copper oxychloride 1:400	1.5 kg/ha	4	0.33	89.46
6. Miltox 1:400	1.5 kg/ha	4	0.94	69.97
7. Blitox 1:400	1.5 kg/ha	1	0.23	92.65
8. Unsprayed control			3.13	
C. D. at p 0.05			0.36	
CV%			14.54	

It is seen from the above that Calixin and Bavistin were practically ineffective. Copper oxychloride (TATA) and Blitox yielded the best control. Miltox was significantly inferior to them. Bangcop and Difolatan was inferior to Miltox.

Branch cankers

(*Poria hypobrunnea* & *Aglaospora aculeata Syn. Tunstallia aculeata*)

Application of PANCIL T a formulation by Indofil Chemicals was made at Tocklai on the pruning cuts following medium pruning. Ability on its protective properties in the subsequent *Poria* infection is under observation. This will be continued.

In Darjeeling application PP. 395, an ICI experimental product, was made at different concentration on medium pruned cuts on a tea garden to study its efficacy in protecting the treated surfaces from *Aglaospora* Syn. *Tunstallia* infection. This will be continued.

Aerobiology

Epidemiological studies could not be made as the spore trap was out of order.

Black rot

During 1975-76 two field experiments were laid out on commercial estates. One experiment with 8 treatments was designed to screen different formulations while in the other different dilutions of copper fungicides were studied for efficacy in controlling the disease.

Screening of formulations : On an area carrying mature tea bushes planted at a spacing (120 × 90 cm) carrying moderate to severe degree of infection, screening of fungicides was undertaken. There were 9 treatments including the untreated control and each treatment was replicated 4 times with 28 bushes in each plot. Two rounds of spray were imposed at fortnightly intervals using Bakpak sprayer. The first round was sprayed on the 28th May 1975 after the infection developed and the subsequent round on the 13th June. The plots were separated by a guard line which received the spray of the adjoining plot but was not observed for the progress of the disease. The results are presented in table 6.

Blitox and Miltox offered the best degree of control 84.81% and 80.30% respectively, followed by copper oxychloride (71.52%). Other formulation studied with the exception of Lorvex offered significant control over the untreated control. The precision of the experiment was not found to be very high. It is proposed to repeat the experiment in the next season to confirm the findings.

Table 6. Degree of black rot infection per bush and percent of disease control

Treatment—rate		Approx. rate per ha. per round	Degree of infection	%infection taking control as 100	%reduction over control
Difolatan	1:1200	870 g/ha	0.97	61.39	38.61
Miltox	1 : 400	2.5 kg	0.31	19.62	80.38
Bangcop	1 : 400	2.5 kg	0.65	41.14	58.86
Copper oxychloride (TATA)	1 : 400	2.5 kg	0.45	28.48	71.52
Blitox	1 : 400	2.5 kg	0.24	15.19	84.81
Calixin	1 : 1000	1 lt	0.71	44.94	55.06
Bavistin	1 : 1000	1 kg	0.76	48.10	51.90
Lorvex	1 : 1600	622 g/ha	1.47	93.04	6.96
Control unsprayed			1.58	100	
C. D. at p = 0.05				0.38	
CV%				32.52	

Mean of 112 bushes per treatment in 4 replicates following two fortnightly rounds of spray.

Effect of different dilutions with hand sprayer

Mature tea bushes carrying moderate to severe infection were used in this trial in which different dilutions of copper fungicides were sprayed at two fortnightly intervals. Treatment No. 6 received 4 rounds of spray at fortnightly intervals. A new Miller chemical Corpn. U.S.A. made sticker Nu-Film 17 (Pinolene) was used (this has tainting effect on tea). Weather on the days of spraying was fair. Shade was rather dense on these sections. Tea was not pruned in 1974 cold weather. The experiment had 7 treatments replicated 4 times each plot containing 32 bushes. The results are presented in Table 7.

Table 7. Effect of copper fungicide at different dilutions and rounds on black rot incidence (Mean of 128 bushes in 4 replicates). Sprayer used Bakpak.

Treatments & dilution	Approx. quantity per ha. per round	No. of rounds	Degree of infection per bush	%infection taking control as 100	%reduction of disease over control
Blitox 1:400	2.5 kg	2	0.27	28.12	71.88
,, 1:600	1.75 kg	2	0.36	37.50	62.50
,, 1:800	1.25 kg	2	0.42	43.75	56.25
,, 1:800 + Pinolene	1.25 kg	2	0.30	31.25	68.75
,, 1:1000	1 kg	2	0.53	55.21	44.79
,, 1:1000	1 kg	4	0.32	33.33	66.67
Control			0.96	100	
C. D. at p = 0.05			0.12		
CV%			18.21		

Control by 1:400 in two rounds is as good as that of 1:1000 in four rounds or with the sticker at 1:800 in two rounds.

Root rots

Soil fumigation studies were initiated in January 1974 in the longest observed experiment which is ready for final observation. In addition there are 4 more trials. In all these trials the soil fumigants used were:

Vapam —Indofil Chemicals
Dichloroethane - NOCIL
Telone — Dow Chemicals
Calixin — BASF Systemic fungicide
Bavistin — -do-
Lithium chloride — a pure chemical

The fumigants are applied at the rate of 8 ml. for perforation of 20 cm deep drilled at a distance of 30 cm. using a crowbar. The hole is closed immediately and lightly watered if the day is hot. Fumigation is carried out into two rows of apparently healthy tea. Here care is called for in not fumigating within 20 cm. radius of the living bush or else phytotoxic symptoms were observed on the living bushes. Systemic fungicides are applied as a soil drench mixed with water to moisten the top 10 cm. of soil.

Five such experiments were laid out.

In addition, some commercial estates are trying some of these chemicals against Charcoal stump rot and Brown root rot. Black root rot is found mostly in Darjeeling and in two exceptional cases in Upper Assam. Teas were replanted during the 12th week following the treatments.

Except for two cases no casuality has been recorded so far in the replanted teas and the growth of the replanted teas is vigorous. Effect of these on the soil microbial populations is yet to be undertaken in detail. On further investigation it was found to be caused by the phytotoxicity of the chemicals applied inadvertantly direct on the root in those two cases.

Blister blight

One trial was conducted in Darjeeling mainly to find out the effective dose and time interval of application of a systemic fungicide (Sicarol 15% dispersion containing 2 methyl--5, 6-dihydro-4-H Pyran 3 carboxylic acid anilide, commonly known as Pyracarbolid). Blitox, Bangcop and Miltox were also included along with hard

Soil fumigation in progress-fumigant is injected at 30 cm. distance (note drilled holes encircled by dots) to a depth of 20 cm.

plucking as treatments. Spraying was started on 29.7.75 when the incidence of blister blight was heavy and the last round was applied on 20.8.75.

The experimental plots consisted of rows of 34 bushes in a 120 × 120 cm. distance. Each treatment was replicated 3 times. Treatment Nos. 1 to 3 and 10 to 12 were applied 4 times at 7 day interval whereas treatments No. 4 to 6 and 7 to 9 received only two applications at 14 and 21 day intervals respectively. Spraying in each case was done with a Mist blower power sprayer following a plucking round. Altogether 5 assessments were made. Results as obtained in the last observation, made one week after the application of the 4th and final round are presented in Table 8.

Four rounds of Sicarol at 700 ml/ha in weekly interval gave the highest reduction of the disease. Weekly applications of Sicarol 15% at 500 ml/ha has yielded almost equal control with Miltox and Blitox applied at 625 g/ha. Of the extended spraying schedule, only Sicarol at 700 ml/ha applied at 14 day interval has offered a similar protection.

Sicarol is however not available yet in the market. Yield records observed during the previous experiments

Table 8. Chemicals for blister blight control. No. of shoots infected out of 100 shoots (Mean of 3 replicates).

Treatments	Rates in ml. or g/ ha per round	Application interval in days	% shoot infected	Percentage reduction
1. Sicarol 15%	300	7	27.00	44.13
2. ,,	500	7	10.66	77.94
3. ,,	700	7	10.33	78.63
4. ,,	300	14	34.00	29.65
5. ,,	500	14	17.00	64.83
6. ,,	700	14	12.33	74.49
7. ,,	300	21	31.00	35.86
8. ,,	500	21	25.66	46.91
9. ,,	700	21	25.66	46.91
10. Bangcop	625 g	7	15.33	68.28
11. Miltox	,,	7	12.33	74.49
12. Bltox	,,	7	12.33	74.49
13. Hard plucking			17.00	64.83
14. Control			48.33	
C. D. at p=0.05			8.08	
CV%			22.52	

confined only to the blister infection period. This does not appear to be a true picture as the plant is likely to make up or deteriorate during the rest of the flushing period. In one experiment, started in 1975, the yield records are being noted for from September 1975 for using as pre-treatment data. Treatments will be imposed during the blister season 1976 and the interaction between treatments, control and yield will be studied.

Bacterial blight of tea

This disease was first noticed in the Borbhetta field nursery in which the deaths were large. It could be brought under control by spraying Streptomycin (5 g Streptomycin sulphate in 5 lit of water)in two rounds. Later this was noticed in another experimental plot at Borbhetta. But to date there was no report of this disease from any commercial tea garden.

Non-symbiotic Nitrogen fixation trials

To evaluate the non-symbiotic nitrogen fixing ability of the much commercially advertised bacterial strains and to compare the performance with those obtained by us from USSR, a pot culture experiment was laid out. Two commercial fertilizers of bacterial base, three strains each of *Beijerinckia* (Russian Strains) and *Azotobactor* were employed. Cultures of *Beijerinckia* and *Azotobactor* were maintained on Jenson's medium. Molybdenum source was avoided for *Azotobactor* cultures.

Garden soil contained in plastic pots was amended with the bacterial cultures and were kept in shade. Watering was done to keep the soil moist. and 3 replicates were maintained. Nitrogen estimation were made at two month intervals using Kjeldahl method. Three replications were analysed for each sample. Untreated pots served as control.

The estimations carried so far did not show any significant difference in nitrogen content. This will be continued during 1976.

It must be borne in mind from the well documented evidence that the bacterial strains fix nitrogen in nitrogen deficient soils only and their ability in low pH soils like those of tea soils is further diminished in the presence of additional inorganic/organic nitrogen supplies.

Miscellaneous

A CSIR Junior Research Fellow has started investigation on the role of agricultural chemicals (fertilizers, pesticides and herbicides) on the soil microflora of tea soils in North East India for Doctoral thesis of the Assam Agricultural University.

Biochemistry Department

RESEARCH AND EXPERIMENT

Biochemical quantification of tea quality

A. Study of Pigment Profile of made tea :

An earlier study of Pigment profile of made teas was reported to the Tocklai Annual Report pp 59-61 of 1973-1974.

The present report deals with the study of pigment profile of Clones TV1, TV11, TV13 and TV16, (light skiffed) manufactured (C.T. C.) at weekly intervals throughout the plucking season of 1975 in the miniature factory of this experimental station and the profiles were analysed in the Biochemistry Department. The profile elute was simultaneously monitored at 380 and 460 n.m. by passing through a flow-through-cell of Autoanalyser fitted with an automatic recorder to trace out the profile.

The experimental samples were tasted by two Tocklai Tasters (A and B) and their evaluations and comments are communicated in the *Summary reports.*

The prediction of quality and flush character was made by the Biochemistry Department independently of taster's evaluation and comments.

On analysing the seventeen reports, it was found that Clone TV 13 is the most susceptable to rains followed by TV11. TV1 and TV16 are not affected by rains very much. The peak quality of second flush remains varying from one week to three weeks depending upon the nature of the clone. It was observed that a clone was hovering between the flushes, for about two weeks before it stabilised in the next flush.

The biochemical predictions as goes by the report regarding quality and flush character are obviously similar in nature with taster's evaluations and comments.

B. Effect of manuring on tea quality

An attempt was made to study the effect of different levels of phosphate on the enzyme response of tea bush. Leaves of the tea bush exposed to two levels of phosphate 45 kg/acre and 180 kg/acre, were analysed for chlorophyll, enzyme (Polyphenol oxidase) activity, theaflavin, thearubigin, polyphenols and amino acids.

Enzymes involved in the biosynthesis of chlorophyll responded the higher doses of phosphate which is evidenced by the Fig. 1. Chlorophyll increases linearly in the P_{180} treated bush right from July when it gets sufficient water. The increase was observed upto the month of November (end of the plucking season). Chlorophyll did not change significantly in P_{45} treated one. On the other hand no perfect order in the enzyme activity and total oxygen uptake were found but comparatively more enzyme activity and total uptake were observed in the P_0 treated bush in the later part of May, June, August and later part of September. Comparatively less fluctuation was found in the enzyme activity of the P_{45} treated bush but marked fluctuation were noticed in the case of P and P_{180} treated bush (Fig.2) throughout the season. Polyphenol oxidase system did not respond to the exogenous phosphate since this system does not require phosporylated compound (ATP etc.) as coenzyme or activator for its activity, whereas the main function of chlorophyll is photophosphorylation. That is why polyphenol oxidase activity did not exhibit any significant response. But at the same time there had been marked increase in the chlorophyll content (from July to November) in the P_{180} treated bush. Our biochemical observations predict that exposure of 45 kg phosphate/acre is suggestive to slightly improve the

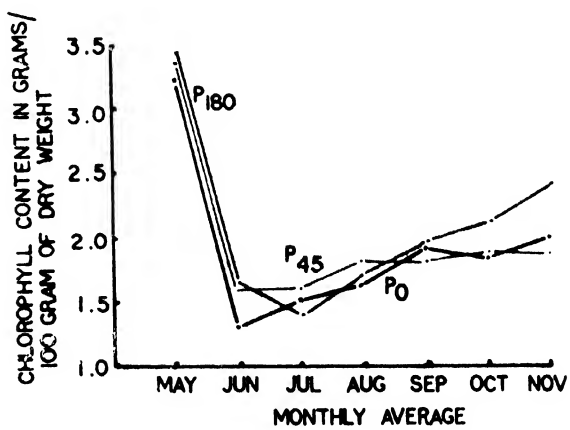


Fig. 1. Chlorophyll Pattern During Season of 1975 under Different Manuring Doses.

quality which is supported by tasters' evaluation (Fig. 3) because chlorophyll content of P_{45} treated bush remained almost constant throughut the plucking season except in the month of May. It has been foun that higher content of chlorophyll is detrimental to th quality which may be the reason for decline in pri

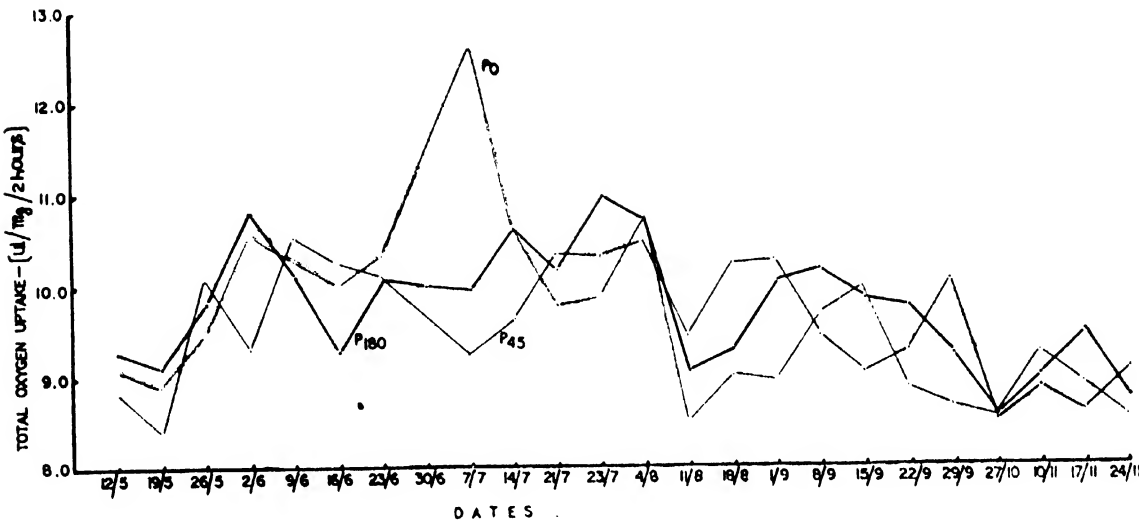


Fig. 2 Total Oxygen Uptake with Different Mannuring Doses During the Season – 1975.

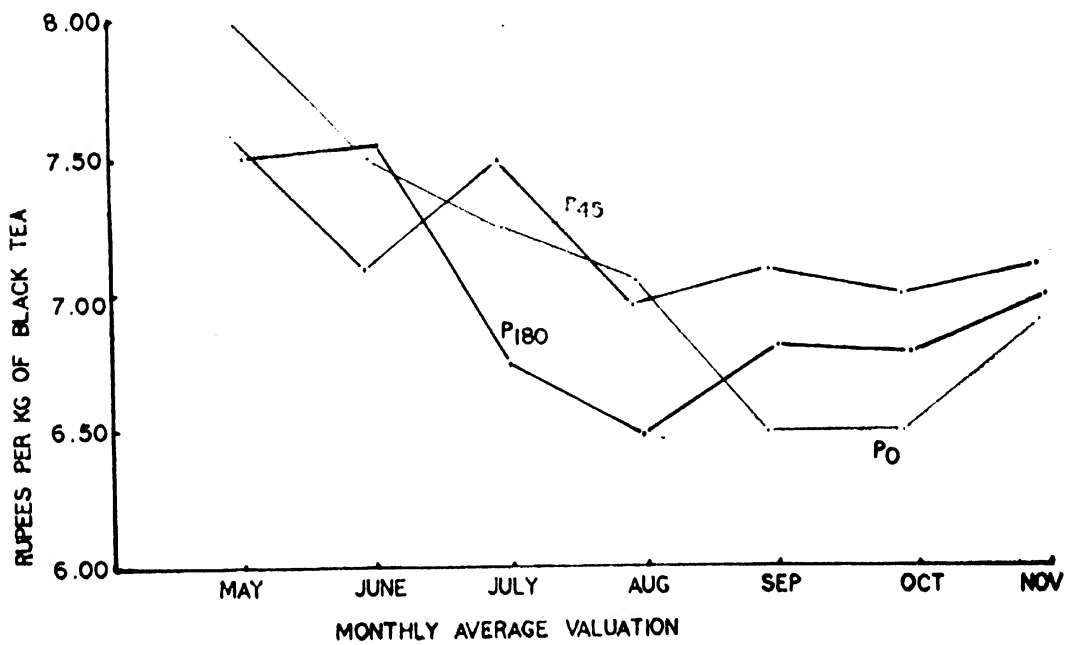


Fig. 3. Tasters Valuation of Tea Made from Different Manuring Doses.

in the P_{180} treated bush. No significant changes were observed in the case of total polyphenols. Amino acid content in P_{45} treated bush was found to be less than in P_0 bush. There was no significant difference in the amino acid content of P_{45} and P_{180} treated bush. TF and TR showed no appreciable variation.

C. Effect of pruning on chemical constituents of fresh tea leaf and its corresponding mape teas

Two clones TV 2 and TV 9, (pruned and unpruned) were, selected for biochemical evaluation throughout the plucking season of 1975.

The analyses for enzyme activity (Q_{02}, ul/mg/hour), total oxygen uptake (ul/mg/2 hour), amino acids, chlorophylls of fresh tea leaf and theaflavins and thearubigins of corresponding made teas were made. In TV 2, it was observed that unpruned bushes contained more polyphenols and more enzyme activity than those of pruned bushes throughout the plucking season. (Fig. 4 and Fig. 6). No significant difference was observed in total polyphenol content of pruned and unpruned bushes of TV 9 (Fig.5). But right from July polyphenol content of pruned bushes was found to be more than the unpruned bushes upto the end of the season, and in the same time TV 9 bushes exhibited more enzymic activity than the pruned bushes throughout the plucking season except in the month of May (Fig. 7). No significant change in the chlorophyll content of pruned and unpruned bushes of TV 2 was observed (Fig. 8), but in the case of TV 9 clone, unpruned bushes exhibited an increasing trend in the chlorophyll content from the middle of June whereas chlorophyll content of pruned bushes were slightly in a decreasing order (Fig. 9). Our biochemical observations based on polyphenol content and polyphenol oxidase activity predict that TV 2 unpruned bushes are slightly better than TV 2 pruned bushes. In TV 9 clone unpruned bushes showed more oxidase activity than in the pruned bushes except in the month of May, but polyphenol content remained almost equal in both pruned as well as unpruned bushes. Theaflavin and thearubigin values were compared in the case of both of the clones TV 2 and TV 9. There was no significant difference in TF and TR values of pruned and unpruned bushes. Amino acid content was found to be slighltly more in the pruned.

From the analytical figures stated above, it was found that TV 2 unpruned is slightly better than pruned, whereas there is no significant difference in the quality of TV 9 unpruned and pruned bushes. However, further work is necessary to arrive at a definite conclusion.

Tocklai Fermentation Test

A new method which is christened as Tocklai Fermentation Test (T.F.T.) had been developed to deter-

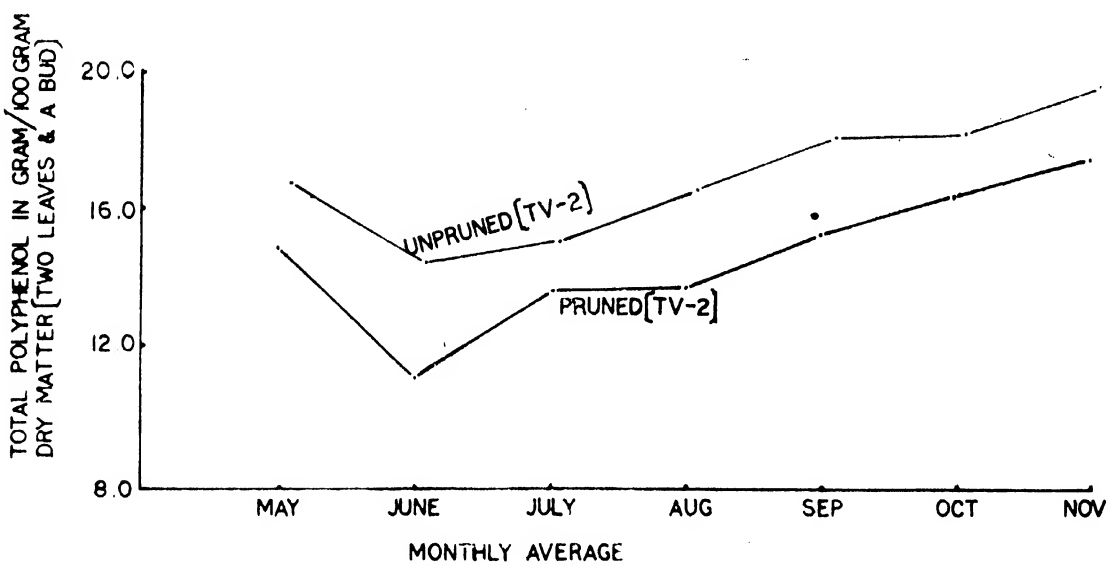


Fig. 4. Polyphenolic Pattern of Pruned & Unpruned (TV 2) 1975.

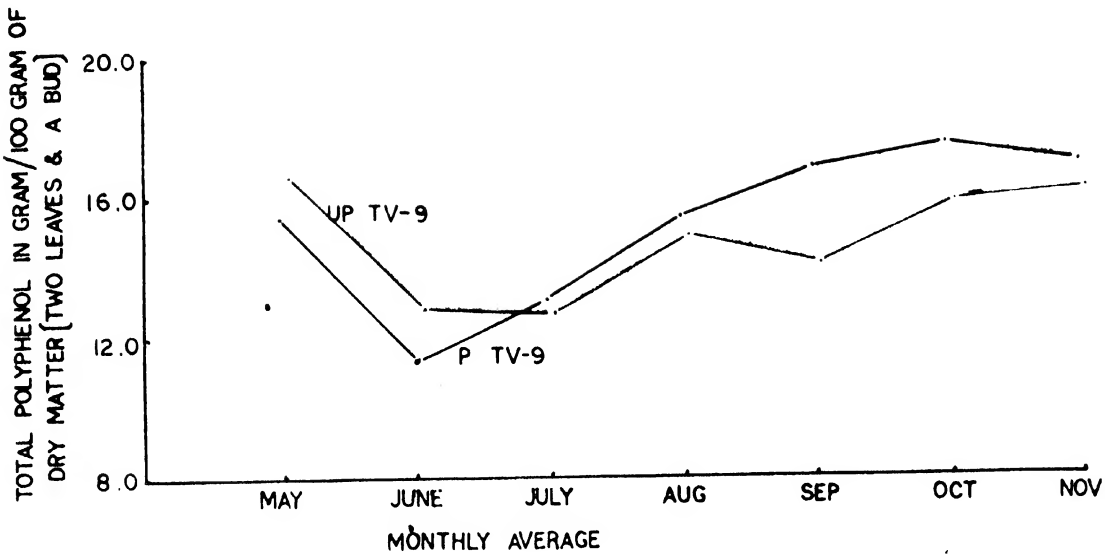


Fig. 5. Polyphenolic Pattern of P & UP (TV 9) 1975.

mine scientifically the correct stage of fermentation to keep the nose of tea makers out.

The phenol reagent develops blue colour with the aqueous extract of fermenting mal with alkali reagent and the colour intensity is highest at the right stage of fermentation in comparison to prior and after the proper stage of fermentation.

To carry out the test, one gm of the fermenting leaf was extracted with 40 ml of boiling water and the colour is developed with 0.3 ml of the extract (infusion) in case

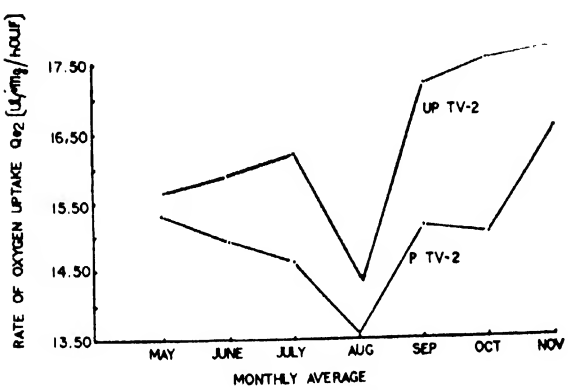


Fig. 6. Rate of Oxygen Uptake of P & UP (TV 2) 1975.

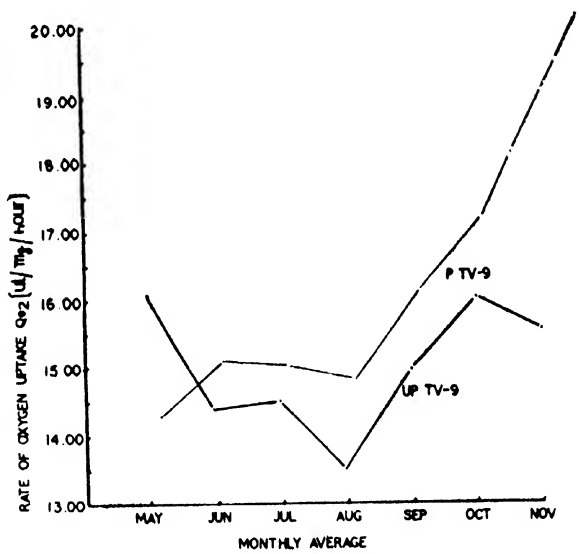


Fig. 7. Rate of Oxygen Uptake of P&UP (TV 9) 1975.

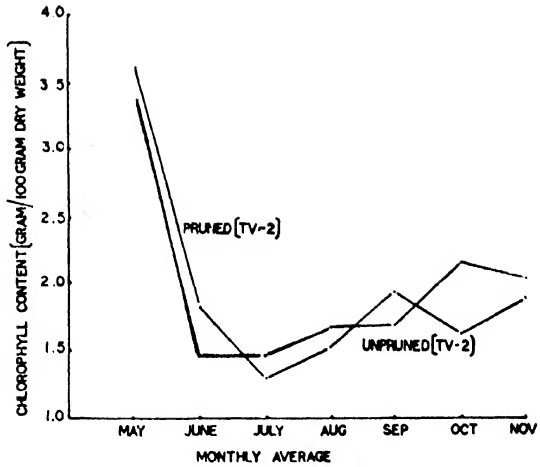


Fig. 8. Chlorophyll Pattern of P & UP (TV 2) 1975

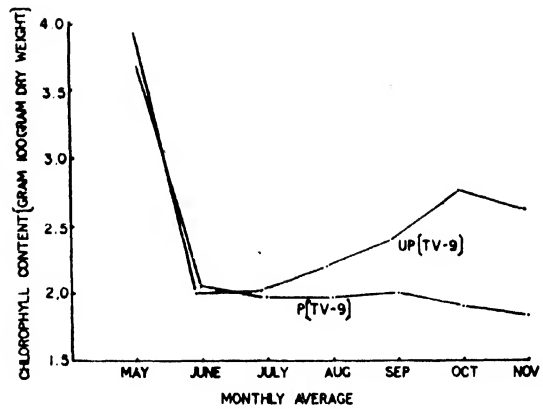


Fig. 9. Chlorophyll Pattern of P & UP (TV 2) 1975

of orthodox manufacture of tea by adding 1 ml of the phenol reagent and 2 ml of 35% sodium carbonate solution and volume is made up to 25 ml. The blue colour thus developed is measured at 700 n.m. using a colorimeter.

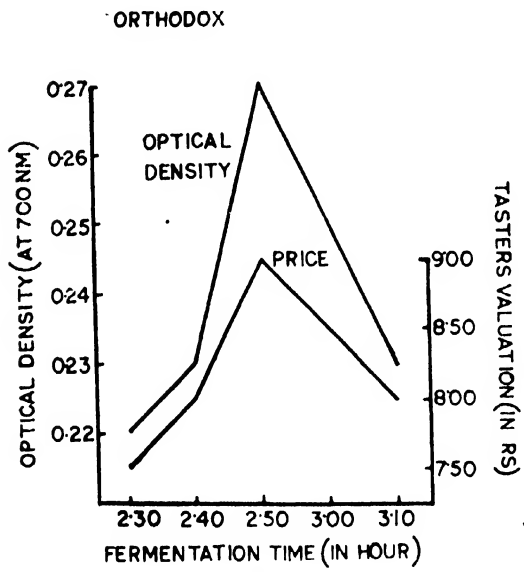
The test had been carried out at different fermentation times for orthodox method of manufacture at the Tocklai Miniature factory for the Clones TV 1, TV 11, TV 13, TV 16 and mixed clones. A correlation was obtained between the maximum colour intensity for right time of fermentation and the evaluation done by the Tea Tasters. Graph I shows the correlation between the price and the optical density (colour intensity) in case of orthodox teas.

Further experiment is under progress for modification and commercial application of the factory floor fermentation method.

Study of total Iron in Tea during different stages of manufacture

To find out the total iron content in tea in different stages of manufacture a number of samples have been analysed which were collected from various tea gardens of North East Plain Region. The important and interesting finding clearly shows that during manufacturing processes starting from green leaf onwards, total iron content has been found to be increasing upto a certain amount.

Since the well known postulation holds the view that the total iron content which was found in green leaf



Graph 1

should not be increased by any means due to various chemical changes that takes place during fermentation. Hence it may so happen that extraneous iron comes from the machinaries used (rolling table, C.T.C. machine, pulleys of conveyer belt and drier) mainly during different stages of manufacturing process. It was found that extra iron particles present in tea was removed by using magnets (Horse-shoe type).

Table 1. Variation of Total Iron content of Tea samples collected from different Tea Estates during different stages of manufacture.

Stages of Manufacture	Iron content in p.p.m. of different Tea Estates					
	C. T. C. Manufacture			Orthodox Manufacture		
	A	B	C	D	E	F
1. Greenleaf (G. L.)	27.5	43	25	30	33	50
2. Withered leaf (W. L.)	28	43	28	32	35	50
3. After Rolling (Roll).	33	55	31	38	50	60
4. After C.T.C. (C.T.C.)	43	155	65	--	--	--
5. After Fermentation (Ferm)	44	160	67	37	50	63
6. Dryer Mouth (D.M.)	48	162	100	35	45	53
7. Graded Dust (G. D.)	48	122	40	48	47	65
8. Tea Waste (T. W.)	75	165	150	120	130	200

Estimation were performed using potassium thiocyanate method, colorimetrically.

A, B, C, D, E, F denotes different Tea Estates.

It is evident from the above table and Figs. (Nos. 10 and 11 for C.T.C. and Orthodox manufacture respectively) that there is sudden increase of iron content in case of C.T.C. manufacture from withered leaf to rolled leaf and more increase of iron content is also observed in C.T.C. cut leaf and which invariably remains unaltered with few exceptions uptil the fermentation is over. Whereas in case of Orthodox manufacture though an increase of iron content is observed from withered leaf to rolled leaf, the iron content remains almost same uptil fermentation is over. During C.T.C. manufacture the contact period between the leaf and machines (first rolling machine then C.T.C. machine) is more than the orthodox manufacture (only rolling machine) and extraneous iron particles are introduced in leaf more in C. T. C. manufacture if the iron particles are available in machine due to various reasons, than the orthodox manufacture. Prior to grading of made tea some Tea Estates are using Horse-shoe shaped magnet under the conveyor belt in different stages to remove iron particles which has been reflected in the Figs. (Nos. 10 & 11). Tea wastes always contain maximum amount of extraneous iron particles as has been shown in figures.

Analysis of samples

Two hundred twenty nine and eighty five tea samples from various departments of Tocklai and Tea Estates were analysed for theaflavin (TFs) and thearubigin (TRs) and moisture content respectively.

Moisture Meter

Kaybee and N-Foss moisture meters from different tea gardens were calibrated during the year.

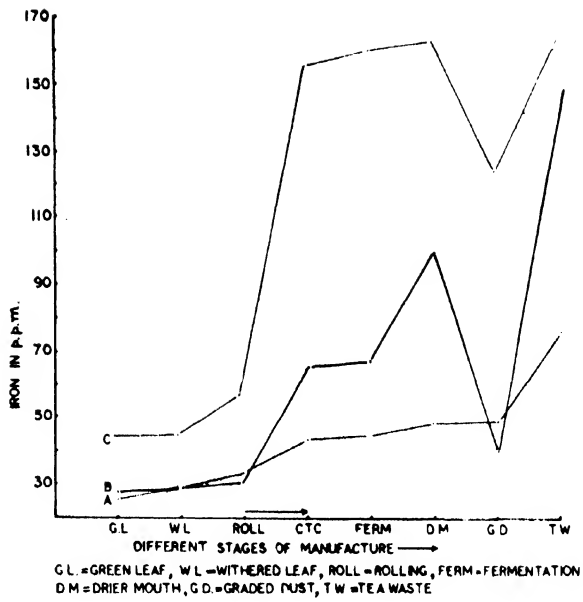


Fig. 10. Total Iron Content (C. T. C.).

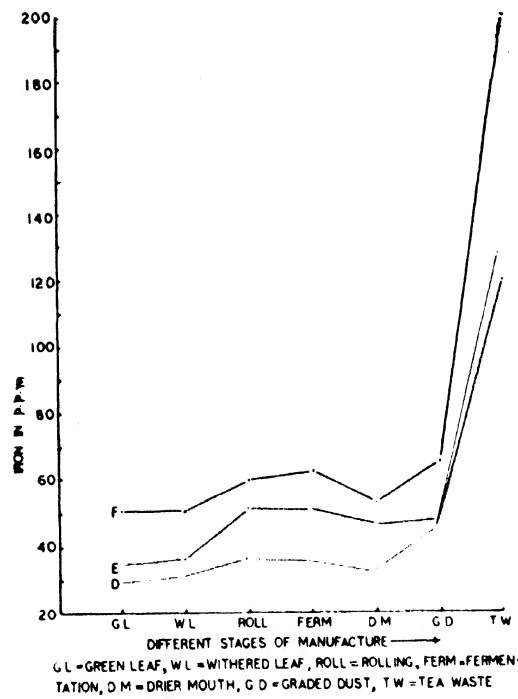


Fig. 11. Total Iron Content (Orthodox).

Summary of Pigment

Clones	TV—1			TV– 11		
Date of Manufacture	Biochemical predictions	Tasters evaluations		Biochemical predictions	Tasters evaluations	
		A	B		A	B
15.5.75	Second flush just starts	Touch of second flush (Rs.7/50)	A touch of second flush (Rs.10/-)	First flush is almost over and approaching towards second flush	(Rs.6/50)	(Rs.6/50)
22.5.75	Second flush character	Second flush (Rs.10/-)	(Rs.11/-)	Approaching towards second flush	(Rs.8/50)	(Rs.8/-)
29.5.75	Pronounced second flush	Second flush (Rs.7/50)	Pronounced second flush similar to TV-1 (Rs.10/-)	Touch of second flush	Second flush (Rs.9/-)	Second flush (Rs.9/-)
5.6.75	Second flush	Good Tea (Rs.10/-)	(Rs.8/-)	Second flush	(Rs.7/-)	(Rs.6/-) Quality deterioated
12.6.75	Improvement in quality	Very strong & pungent represent the characters of TV—1 (Rs.10/-)	(Rs.8/-)	No improvement in in quality	(Rs.7/-)	(Rs.7/-)
19.6.75	Last stage of second flush better than (TV—16)	Touch of second flush (Rs.9/-)	Falling of seasonal character (Rs.8/-)	Initial stage of rains	(Rs.6/-)	No seasonal character (Rs.7/-)
26.6.75	Second flush	Some Second flush character (Rs.8/50)	Some Second flush character (Rs.8/50)	Initial stage of rains	Touch of a flush (Rs.7/50)	Touch of second flush (Rs.7/50)
3.7.75	1st stage of rain flush	Rains Tea (Rs.8/50)	Deteriorated TV-1 (Rs.8/50)	Rains flush	Rains Tea (Rs.8/-)	Touch of a flush (Rs.6/50)
10.7.75	Rain flush	Touch of second flush (Rs.8/-)	Deteriorated character (Rs.8/-)	Rains flush	No second flush character (Rs.6/50)	No flush character (Rs.7/50)
17.7.75	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.8/-)	Rains flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.7/50)
24.7.75	Rain flush but quality is not affected	Rains Tea (Rs.8/-)	Rains Tea (Rs.7/75)	Rains flush regained their quality from the previous one	Rains Tea (Rs. 8/-)	Rains Tea (Rs.5/50)
31.7.75	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.7/50)	Rain flush	Rains Tea (Rs.6/)	Rains Tea (Rs.5/50)
7.8.75	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.8/-)	Rains flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.7/-)
14.8.75	Rain flush (Last stage)	Rains Tea (Rs.8/-)	Rains Tea (Rs.7/50)	Rains flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.5/30)
21.8.75	Rain flush	Not available		Rains flush	Not available	
28.8.75	Approached autumn	-No comments- (Rs.8/-)	(Rs.8/-)	Approached autumn	-No comments- (Rs.6/50)	(Rs.6/50)
4.9.75	Autumn	-No comments- (Rs. 8/-)	(Rs.8/-)	Autumn flush	-No comments- (Rs.7/50)	(Rs.7/-)

Profile Stuides

TV 13			TV 16		
Biochemical Predictions	Tasters evaluations		Biochemical predictions	Tasters evaluations	
	A	B		A	B
First flush	(Rs.6/50)	(Rs.6/50)	Second flush character	Touch of second flush (Rs.7/50)	A touch of second flush (Rs.10/-)
Touch of second flush	(Rs.7/-)	(Rs.8/-)	second flush	second flush (Rs.10/-)	A touch of second flush (Rs.9/-)
Touch of second flush	Second flush (Rs. 7/-)	Slight second flush (Rs. 8/-)	Pronounced second flush	Second flush (Rs. 12/-)	Pronounced second flush (Rs.11/-)
Second flush	(Rs.6/50)	(Rs.7/-) Quality deteriorated	Second flush	Good flavour (Rs.9/-)	(Rs.8/-)
No improvement in quality	(Rs.7/-)	(Rs.7/-)	Improvement in quality	(Rs.8/-)	(Rs.8/-) No coment
Initial stage of rains	(Rs.7/-)	(Rs.7/-)	Initial stage of rains	Second flush character-less than TV—1 (Rs.8/50)	Falling of seasonal character (Rs.8/-)
Rain flush	Touch of a flush (Rs.7/-)	Doubt have any flush character (Rs.6/50)	Second flush	Some second flush character (Rs.8/-)	Touch of Second flush (Rs.8/-)
Rain flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.6/50)	Ist stage of rain flush	Rains Tea (Rs. 8/50)	Deteriorated TV 16 (Rs.8/-)
Rain flush character	No comment (Rs.7/50)	No flush	Rain flush	Touch of second flush (Rs.8/50)	Deteriorating TV-16 (Rs.8/-)
Rain flush	Rains Tea (Rs.6/50)	Rains Tea (Rs.7/50)	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.8/-)
Rain flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.6/50)	Rain flush but quality is not affected	Rains Tea (Rs.7/-)	Rains Tea (Rs.7/-)
Rain flush	Rains tea (Rs.7/-)	Rains Tea (Rs.6/75)	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.7/50)
Rain flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.6/50)	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.7/50)
Rain flush	Rains Tea (Rs.7/-)	Rains Tea (Rs.5/30)	Rain flush	Rains Tea (Rs.8/-)	Rains Tea (Rs.6/50)
Rain flush Approached autumn	Not available No comments— (Rs.7/-)	(Rs.7/-)	Rain flush Approached autumn	Not available -No comments- (Rs.8/-)	(Rs.7/50)
Autumn flush	-No comments- (Rs.6/50)	(Rs.6/50)	Autumn flush	-No comments- (Rs.8/-)	(Rs.7/50)

Tainting of teas due to use of different commercial products both in field and factory

Experiments were conducted during the year under review to test the suitability of solid woven cotton conveyor belting in a commercial factory with particular reference to taint in made tea during conveyance. No such taint was detected in these trials and as such this material can be safely used for conveying dried black teas.

Agro-chemical

Experimental tea samples made from leaves of tea sprayed with different pesticides were tasted for taint in the made teas. In these trials 28 samples were included and this work was carried out in co-ordination with the Entomology Department. Only two of the sample products, ₹X-factor and Nu-film tainted the made teas.

Packaging and storage

Search for alternative packaging materials continued during 1974-75. In addition to the materials included during the preceding year, a few more were tested. These could be grouped as follows :

Table 1. Taster's evaluation of teas packed in different paper materials for lining.

Val. in Rs./kg.

Material / Taster	Plasticoated opaque glassine paper	Plasticoated white paper	Plasticoated multi-guard/kraft/poly paper	Normal plywood tea chest & Lining
Tocklai	6/17	6/33	6/50	7/-
W. Bengal	8/25	7/25	8/-	8/-
Gauhati	6/50	5/-	5/-	7/50

Table 2. Moisture content of the stored tea in normal plywood tea chest using different papers as lining.

Materials	During packing	After 1 month	After 2 months	After 3 months
Plasticoated opaque glassine paper.	3%	3.24	3.44	3.84
Plasticoated white paper	3%	3.44	3.70	4.07
Plasticoated multiguard/kraft/poly paper.	3%	3.16	3.35	3.75
Normal plywood tea chest and lining	3%	3.03	3.34	3.43

I. Paper material for lining.
II. Hessian/plasticoated bag for storage of tea.
III. Flat jute tea bags/polythene laminated.

None of the materials used as lining for packaging imparted any taint to the made teas. From the taster's evaluation and the moisture content ascertained at one month, two months and three months storage of the packed tea it follows that valuations of the teas packed in plywood tea chest using normal lining always remained highest. As can be seen from table 12, moisture content under normal storage increased gradually with the time of storage, but this increase was always lower compared to moisture increase in experimental samples at each date of sampling.

Table 3. Taster's evaluation of teas packed in different hessian bags.

Val. in Rs/kg.

Material / Taster	Bitumen hessian bag	Plasticoated multi-guard (kraft/poly/ carpet backing hessian bag	Polylaminated hessian bag	Polycoated hessian bag	Normal plywood tea chest & lining
Tocklai	6/80	6/33	Tainted	Tainted	7/-
West Bengal	8/-	8/-	Tainted	Tainted	8/-
Gauhati	6/-	5/25	Tainted	Tainted	7/50

Table 4. Moisture content of the stored tea in different Hessian bags.

Materials	During packing	After 1 month	After 2 months	After 3 months
Bitumen hessian bag	3%	4.80	5.50	6.57
Plasticoated multiguard (kraft/poly/carpet backing hessian bag.	3%	4.77	5.43	5.24
Polylaminated hessian bag	3%	5.11	6.20	6.98
Polycoated hessian bag.	3%	5.55	5.64	6.50
Normal plywood tea chest and lining	3%	3.03	3.34	3.43

Polycoated hessian bag, Polylaminated hessian bag used for packing tainted the made tea and as such these are unsuitable for use. The remaining two samples of hessian bag did not taint the made tea. It can also be observed from the Table 4 (M. C.) that the absorption of moisture was significantly higher with the sample materials tested than the normal plywood tea chest samples used as controls.

Table 5. Taster's evaluation of teas packed in different jute fabric bags.

Val. in Rs/kg.

Material / Taster	Two sides high density polythene laminated on high bleached jute fabric	One side high density polythene laminated on full bleached jute fabric	Both sides high density polythene laminated on full bleached jute fabric	Both sides high density polythene laminated on highly bleached jute fabric	Normal plywood tea chest and lining
Tocklai	6/17	5/60	6/80	6/17	7/-
West Bengal	8/-	8/-	7/25	8/-	8/-
Gauhati	5/-	6/25	6/25	5/-	7/50

Table 6. Moisture content of the stored tea packed in different jute fabric bags.

Materials	During packing	After 1 month	After 2 months	After 3 months
Two sides high density polythene laminated on high bleached jute fabric	3%	4.54	4.70	5.81
One side high density polythene laminated on full bleached jute fabric	3%	4.67	5.44	6.43
Both sides high density polythene laminated on full bleached jute fabric	3%	4.77	5.64	5.93
Both sides high density polythene laminated on highly bleached jute fabric	3%	4.23	4.83	5.61
Normal plywood tea chest and lining	3%	3.03	3.34	3.43

The jute fabric bags were tested in the similar way as the other experimental materials reported above and in this instance the tea did not pick up taint even after the storage period of three months. It can be seen here that the excess moisture absorption followed the same pattern as the experimental hessian bags. The significant increase of moisture content and the lower valuations of tea when stored in the experimental samples compares to the normal samples do not account for their suitability of use.

Some physical disadvantages were found evident from the storage of tea in bags. These were as follows :

(1) Hand stitched hessian bags after one month storage developed gaps during storage which permited absorption of moisture to a greater extent. The excess absorption of moisture was confirmed by determining the moisture content of teas in bags. Some sort of mechanical stitching would probably be beneficial as this might ensure better dealing and reduce the possibility of the moisture getting through the month of the bag.

(2) It is not possible to draw out representative samples from the centre of the tea stored in bags which is a normal procedure for drawing samples from plywood tea chest. This certainly is a disadvantage for storage of tea in bags.

(3) Storing in bags has obvious disadvantage due to the damage caused to the tea, particularly to the leaf grades by the pressure exerted during stacking.

On the whole the normal plywood tea chests were considered superior as a protective storage material and aluminium lining as a moisture barrier compared to all the experimental samples referred to above.

Long term trial

Under this trial biclonal stocks were evaluated on samples of tea sent for assessment of liquor characters. Samples from green leaf of the biclonal stocks were manufactured in the miniature factory.

Selection of clones

This department lent active support to Botany department in selection of vegetative clones; leaf samples were manufactured in the miniature factory both in Orthodox and CTC method and continued throughout the season. These samples were tasted to help evaluation of the new selections of Botany department. It was also suggested to continue the selection work under long term programme.

Long term trial of clones

Out of the proposed six long term trials, samples from three long term trials of clones were manufactured in the miniature factory and tasted for evaluation. Four clones among the series were found to be outstanding in cup character in the preliminary trial. The trial is proposed to be continued.

Continuous Tea Roller

Made tea samples processed from Continuous Tea Roller under commercial trial at Borbam T.E. were tasted and evaluated for the Engineering Research and Development Department.

Management practices and Biochemical experiments

A total of 894 clonal leaf samples were manufactured in the miniature factory for the studies of the pigment profile, pruning cycle and manuring expt. Tocklai fermentation test etc. Clones TV1, TV2, TV9, TV11, TV13 and TV16 were included in these trials.

Effect of cultural practices

Leaf samples from the experiments on the effect of P & K on quality of tea, Long term weedicide, Effect on zinc were manufactured both by Orthodox and CTC processes in the miniature factory. Made tea samples were also tasted and reported for the Agriculture Department.

Evaluation vis-a-vis commercial products

The following commercial products were tested during the manufacturing season :

(1) Epoxide Chemical Resistant Paint—received from Shalimar Paints Ltd., Pan Bazar, Gauhati was tested as a paint for painting fermenting floors in tea factories. Only a few limited repeat experiments were done which necessitates further tests. Therefore the test will be continued for the next manufacturing season.

(2) Polyform Water Proofing Compound –received from Ablative Polymer Products (India) Pvt. Ltd., 13, Woodburn Road, Calcutta-700020 was tested to use for spreading of fermenting leaf on it in tea factories. Further tests are necessary to arrive at a definite finding.

(3) "Clean Well"—received from Merit Chemical Works, Tarapukar Road, Agarpara, 24 Parganas, Calcutta. The cleaning powder has a high pH value (pH of 9.7) as such it is not considered suitable for cleaning rollers, fermenting surfaces in tea factory.

(4) 'Safai' as such is recommended by Tocklai. A sample of Safai received from Choibari T.E. was tested and found to contain a high pH. Under such conditions it must be ensured that the surface of the fermenting room is thoroughly cleaned with clean water to remove any residue likely to remain on it, otherwise a trace of it will have an adverse effect and cause the tea to become black in colour.

Tea Tasting

During the season 12145 samples were tasted. This consist of 4175 samples from Tocklai, 5926 from estates for advising on manufacture and 2044 clonal samples from estates.

Altogether twelve Tea Tasting Sessions were held in different areas arranged by the different Area Scientific Committees in respect of experimental as well as commercial samples. Regular weekly group tasting sessions were also held at Cinnamara factory during the manufacturing season.

Seven Seminars on Enginering and Tea Manufacture were held. The Deputy Director and Tocklai Tea Tasters attended the seminars. The venues of these seminars included Tocklai, Upper Assam, North Bank, Dooars, Terai and Darjeeling.

Engineering Research and Development Department

Continuous Green Leaf Processing Machines

(a) **Continuous Tea Roller :** The 45 cm Prototype Continuous Tea Roller was set up at Borbam T. E. and was tried out there throughout the season. After some initial mechanical troubles which were sorted out quickly, some further modifications were done to improve its performance during the first roll, as it was seen that while the results of the second and subsequent rolls were very good the machine has some potential to improve its first fines. These modifications include an extra device for adjustment of pressure during rolling. After these modifications the performance of the machine has greatly improved as can be seen from the tasters' valuations of the samples given in the following table.

Monthly average valuations Rs/kg

	1st Fine		2nd fine		3rd fine		C. T. C.	
	C.T.R./	Normal	C.T.R./	Normal	C.T.R./	Normal	C.T.R./	Normal
May	8.00	9.33	7.41	8.33	—	—	—	—
June	8.67	10.33	8.63	9.17	7.67	8.17	—	—
July	8.16	8.70	7.36	8.20	7.33	7.10	6.56	6.72
August	7.33	8.00	6.63	6.93	—	—	6.19	5.89
September	8.91	8.95	8.12	8.50	—	—	7.05	7.27
October	8.50	8.91	—	—	—	—	7.50	7.25
November	8.88	9.12	—	—	—	—	7.20	6.76

It can be seen from the table how the performance of the Continuous Tea Roller has improved during the year. The performance gap in case of orthodox fines has reduced greatly, while in case of C.T.C. tea from the coarse mal the performance of the CTR is found to be better than the conventional roller. The monthly average valuations in the above table does not really give a true picture, because from the tasting reports of the day to day samples it was found that from the later part of August the performance of the machine not only caught up the performance of the conventional rolling table, but also more number of times preference was given to the Continuous Tea Roller samples than to corresponding normal samples, as can be seen in the table

Monthwise No. of preferences of C. T. R. samples

Month	No. of comparative sets of samples				No. of C. T. R. samples valued equal to or higher than normal samples			
	1st fine	2nd fine	3rd fine	C.T.C	1st fine	2nd fine	3rd fine	C.T.C
May	6	6	0	0	1	0	0	0
June	3	3	3	0	1	1	1	0
July	5	5	3	5	1	1	2	2
August	15	13	2	10	6	4	1	7
September	12	4	0	11	8	2	0	5
October	6	0	0	2	2	0	0	1
November	4	0	0	5	2	0	0	4

Continuous Tea Roller

It can therefore be said safely that at this stage this machine is in a position to replace the conventional batch type rolling table and the day is not too far off when the method of orthodox tea manufacture will be continuous.

One problem faced during the trial was that while we need two machines in tandem for the two passes necessary for the first roll we had only one machine and the leaf had to be collected after the first pass in a trolley for about half an hour and then put back in the same machine for the second pass. In doing so, the leaf gets heated up in the trolley and loses some character. Therefore to realise the full potential of the machine it was decided to build one more prototype and then to try the two together in tandem during the next season. Hence, a second prototype of 37 cm. size was built and was shifted to Borbam T. E. by the end of the year. This second prototype is made smaller than the first, because during the second pass the capacity of the machine is found to be double of the capacity during the first pass.

It is hoped that the 37 cm machine, when used for the second pass can cope with the output of the 45 cm machine used for the first pass.

In the mean time patents for the Continuous Tea Roller have been obtained in India, Iran, Malawi, Zambia and Zaire.

(b) **Disc Type Continuous Roller**

The 122 cm (48") commercial prototype Disc Roller was installed at Satali T. E. Dooars and was tried out during the later part of the season. Tocklai Tasters' valuations of the few sets of comparative samples received from there are given in the following table.

Valuations in Rs/kg

Date	2nd fine		Coarse	
	Conventional	Conventional + Disc	Conventional	Conventional + Disc
9.10.75(a)	7.50	8.50	8.00	7.00
9.10.75(b)	7.50	8.00	-	-
10.10.75(a)	7.00	8.00	7.00	7.50
10.10.75(b)	8.00	7.50	—	—
Average	7.50	8.00	7.50	7.25

This machine has now been transferred to Nonaipara T. E. in the North Bank for trial during the next season.

Commercial production of the 122 cm (48") Disc Roller has been started at Port Engineering Works, Calcutta. After some initial delay due to shortage of raw material and power cuts, the first machine was produced during the middle of the year and was installed at Itakhooli T. E. Report on its performance is still awaited.

In the mean time further trials were taken up with the 76 cm (30") prototype Disc Roller fabricated at Tocklai. With a view to have better twisting action the shape of the discs and the battens were modified and then the roller was tried out for second and third rolls after the first roll in a normal conventional roller. These teas were compared with the conventional second and third fines. The comparative valuations given by Tocklai Tasters are given below.

(c) **Cutter attachment for B.L.C. & Rotorvane**

The first commercial unit of the cutter attachment for B. L. C. was installed early during the season at Leesh River T.E. in Dooars on C.T.C. manufacture. Initial trials indicated a few teething troubles. But after the second set of rotor and starter blades were removed the output was reported to be 1100 kg/hr. The cut obtained was equivalent to that obtainable from the first C.T.C. cut.

Valuations in Rs/kg

Date	2nd fine		3rd fine		Coarse	
	Conventional	Conventional +Disc	Conventional	Conventional +Disc	Conventional	Conventional +Disc
6.7.75	11.00	12.00	10.00	9.50	8.50	9.50
8.7.75	11.50	10.50	9.50	8.50	9.50	8.00
11.7.75	9.50	11.00	9.50	9.00	9.00	8.00
6.8.75	9.00	10.00	9.50	8.50	8.00	8.00
18.11.75	9.50	10.00	7.00	9.50	8.50	8.00
20.11.75 (a)	10.50	8.00	9.50	10.00	9.50	8.00
20.11.75 (b)	9.50	9.00	9.00	8.00	8.50	8.50
28.11.75	8.50	9.50	9.00	9.50	7.00	8.00
3.12.75	9.00	9.00	9.00	9.00	8.50	6.30

The subsequent commercial units made of Manganese Bronze and fitted to B.L.C. and Rotorvane also had some initial troubles. With Rotorvane the difficulties were quickly overcome by reducing the number of radial blades in the cutter plates. But, for improved performance of the attachment with B.L.C. further modifications were necessary. A commercial unit of B.L.C. and cutter attachment was brought from Port Engineering Works on loan for that purpose, and after doing the necessary modifications was tried out at Tocklai. Some changes in the B.L.C. were also necessary to adapt the modified attachment to it. The trials showed that the output of the machine has increased upto 1600 kg of rolled leaf per hour while at the same time the performance of the machine improved substantially as can be seen from the following table giving Tasters' comparative valuations of Roll + B.L.C. + Cutter attachment C.T.C. teas, cut twice in C.T.C. machine and normal roll + C.T.C. teas, cut thrice in C.T.C. machine.

Valuations in Rs/kg

Date	Roll + B.L.C. with Cutter attachment +C. T. C. (2 cuts)	Roll + C.T.C. (3 cuts)
Before modification		
7.11.75	6.50	8.00
After modification		
25.11.75	8.00	7.00
4.12.75	7.50	7.00

The whole machine has since been sent back to Port Engineering Works for incorporating these modifications in their newly manufactured machines.

The alloy Manganese Bronze used for making the cutter attachment did not prove its good wearing properties for this particular application and hence it is now decided to use stainless steel for the commercial manufacture of this attachment.

(d) **Withered leaf Preconditioner:** The work of fabrication of the prototype Preconditioner with 8 pairs of rollers was completed early in the season and was installed at Dufflaghur T.E. in the North Bank for comparative tests under commercial conditions of manufacture. Tasters' valuations of all the comparative samples received are shown in the table below:

Valuation in Rs/kg

Date	1st fine		2nd fine		3rd fine		Coarse	
	With pre-conditioner	Without precondi-tioner	With pre-conditioner	Without precondi-tioner	With pre-conditioner	Without precondi-tioner	With pre-conditioner	Without precondi-tioner
20.5.75	8.00	9.00	8.00	9.00	—	—	8.00	8.20
27.5.75(a)	10.00	9.50	8.50	8.00	—	—	7.00	7.50
27.5.75(b)	11.00	10.00	9.50	10.00	—	—	8.50	8.00
28.6.75	10.00	8.50	13.00	11.00	12.00	11.00	7.50	7.00
24.7.75	10.00	8.50	9.00	8.50	9.00	8.00	8.00	7.00
26.7.75	10.00	9.00	9.50	8.50	9.00	8.00	8.00	7.00
31.7.75	9.50	9.00	9.50	8.00	8.00	7.00	7.50	7.00
11.10.75	8.50	7.75	8.00	8.75	7.50	7.50	8.00	7.00
Average	9.63	8.91	9.38	8.97	9.10	8.30	7.81	7.34

It has now been decided to try out this device along with the Continuous Tea Rollers to see if after preconditioning the leaf whether one pass through the Continuous Tea Roller can complete the first roll. Arrangements are being made to shift the withered leaf Preconditioner from Dufflaghur T.E. to Borbam T. E.

Fermentation

Continuous Fermenting Machine : A formal agreement has been made between the TRA and M/s Tea-Ma Consortium India Ltd. for the commercial manufacture of the Continuous Fermenting Machine. The other earlier licensee M/s Steelsworth Ltd. is yet to start manufacturing the machine.

Plucking

Power Operated Plucking Aid

The first unit of the power operated plucking Aid developed by our collaborator M/s Shaw Wallace & Co. Ltd., Madras has been received during the middle of the season and was tried out at Borbhetta. The report from the Agronomist is reproduced below :

1. The output of the machine is less than that of a manual plucker. Output is approximately 1.2 to 1.8 kg/hr.

2. The machine takes 1.2 minutes to pluck a youngish mature tea bush whereas a plucker takes only 30-40 seconds to finish the job.

3. While in operation the operator cannot see the plucking table lying immediately in front of him. As a result the operator has to run the machine over the plucking table without seeing it. In that process lot of shoots are left untouched by the cutter. To cut it completely, the operator has to go round the tea bush several times. More time is being consumed in his way.

4. The lower plate with the fingers keeps the machine well above the bush surface. As a result the cutter misses many ready shoots. The cut surface becomes uneven and high.

5. Also the lower plate and the fingers bend the shoots and as a result the cutter misses the shoots. To cut these missed shoots the operator has to go round the bush several times.

6. In young tea if the operator wants to have a close cropping, then the lower plate with the fingers bends the whole top hamper. Cutting becomes uneven and difficult.

7. The engine has less revolution.

8. The engine stops frequently as the blades of the cutter get choked with the cut leaves.

9. The cotton bag which is attached gets tangled with the branches and also falls off frequently from the hooks.

10. The bush surface is damaged considerably. The stems are shredded.

11. In the plucked leaves the fine percentage is only 10%. The rest is coarse leaf, including shredded bits

of stems, leaves janam with stems, bits of shoots and mature leaves.

This report has been submitted to M/s Shaw Wallace & Co. Ltd., Madras to point out the areas where further development work is necessary.

Miscellaneous

Seminar : A seminar on Engineering Problems of the Tea Industry was held at Tocklai from the 21st April to the 23rd April 1975. The list of invitees included Members of the Council of Management of the Tea Research Association, Members of the Agriculture and Engineering Sub-Committees, Tea Tasting panels, Planters representatives from all the nine area scientific committees, representatives from all the nine area scientific committees, representatives of the leading and functional Tea machinery manufacturers, accessory manufacturers, service Engineers of the various Agency Houses and their representatives. Special invitees were Dr. S. K. Suri of the National Physical Laboratory and Dr. J. H. Agarwal of Jawaharlal Nehru Agricultural University. They are Specialists in Instrumentation. The deliberations were highly educative, informative and fruitful. In all eight papers were presented in the seminar.

A sub-committee consisting of nine members was constituted after the seminar was over to delineate the priorities for the Engineering Research and Development Department for the immediate future. The report has since been submitted and is undergoing scrutiny. The final recommendations of the committee are given below :

Priorities

Field

Plucking aid with re-chargeable battery.

Factory : Green Leaf Processing

1. Green Leaf Sorting device to be developed paripassu with the plucking aid.

2. Continuous method of Green Leaf Processing for Orthodox manufacture.

3. Reducing weight to product ratio of existing machines, mainly green leaf processing machines, by using materials like fibre glass etc.

4. Reducing power requirement of leaf processing machines like CTC, LTP etc.

Fermentation

Investigation and study of the fermenting process-effect of heat, air flow, relative humidity etc.

Drying :

1. Improvement in existing system of drying with particular reference to fuel economy and out-put.

2. Waste heat recovery.

3. Alternative methods of burning fuel,—use of different types of grates for coal or high pressure oil burner, pulverised coal burning equipment.

4. Investigation into new types of dryers—like the ones described by Mr. Kar and Mr. J. Barooah.

5. Investigation into biochemical changes during drying process so that necessary alterations/ adjustments can be made to the existing drying machines.

6. Investigation into the use of alternative fuel Like LPG.

7. New techniques of drying like the fluid bed method etc.

Sorting

Machines for extracting stalks from Orthodox teas.

Instrumentation

Committee to look into the use/adoption of existing instruments for use in tea.

Packing

Development of alternative packing material.

General

The Senior Research Engineer attended a seminar on utilisation of solar Energy at Madras, where he presented a paper on "Possibilities of Application of Solar Energy to Tea Industry". He also presented a paper in the 27th Tocklai Scientific Conference. He visited Calcutta four times and Tinsukia once in connection with the matters relating to the manufacture of Tocklai developed machines. He attended six seminars held under different Area Scientific Committees on Engineering and manufacturing problems and two other A.S.C. meetings. During the year he paid visits to 24 factories

in connection with engineering and manufacturing problems.

The Second Research Engineer visited Darjeeling for one month to make a survey of the problems of Darjeeling Tea Manufacture. He covered 19 gardens in this survey and prepared a report covering all the aspects of Darjeeling Tea Manufacture. The report has already been submitted. He also presented a paper in the 27th Tocklai Scientific Conference and attended a seminar on Efficient Use of Fuel at Panitola given by the National Productivity Council. He attended one A.S.C. meeting during the year. Apart from his visits to Borbam T.E. in connection with his experiment of the Continuous Tea Roller he paid visits to 10 factories in connection with engineering and manufacturing problems.

The Senior Research Engineer was on leave for four months during the end of the year preparatory to his retirement on the 31st March, and the Second Research Engineer was in charge during that period.

Statistics Department

Sampling and Experimental Technique

Sampling of plucking rounds : The object of this study was reported in the Annual Scientific Report for 1973-'74, p. 69, i.e., to find out whether it is possible to make treatment comparisons from part yield of the whole season or not, in order to minimise the time and expenditure without any appreciable loss of experimental accuracy. Detailed study based on 17 long-term experimental data carried out for 4 to 13 years, covering the period 1951—'72, conducted in the tea estates of Assam Valley, Cachar, Dooars, Darjeeling and in the Experimental field of Borbhetta continued during the year. The age of the bushes in these experiments covered a wide range between 3 to above 63 years which included experiments on fertiliser, pruning cycle and type, plucking and cultivation.

The whole season's crop was divided into two parts in various ways and the procedure of division has been shown in Table 1.

Table 1. Description of type of division of whole season's crop.

	Crop period formed with						
One month*		Two months*	Three months*	Four months*	Five months*	Six months*	Seven months* (Whole season's crop)
Upto May	(M)						
June	(J)	M+J					
July	(JL)	J+JL	M+J+JL				
August	(A)	JL+A	J+JL+A	M+J+JL+A			
September	(S)	A+S	JL+A+S	J+JL+A+S	M+J+JL+A+S		
October	(O)	S+O	A+S+O	JL+A+S+O	J+JL+A+S+O	M+J+JL+A+S+O	
Nov3mber & December	(ND)	O+ND	S+O+ND	A+S+O+ND	JL+A+S+O+ND	J+JL+A+S+O+ND	M+J+JL+A+S+O+ND

*X_1 = One crop period.
X_2 = Second crop period = whole season's crop-crop of X_1

As for example, from the table (Table 1) it can be seen that crop upto May = X_1 (say), is taken as one part of the whole season's crop, and the second part crop is the remaining crop of the whole season, i.e., X_2 (say) whole season's crop-X_1. In this way the whole season's crop was divided into two parts, taking, in general, one to six months crop at a time as the one part crop and the second part was the remaining crop of the whole season. Thus, there were 21 distinctly different types of division of whole season's crop out of 27. Analyses were carried out separately for each part crop of all the 21 types of division and also for the whole season's crop both for individual year as well as for combined analysis over the period of experimentation of all the 17 experiments.

At the first stage, the results of combined analysis over years of experimentation of each experiment were examined for each part crop of the 21 types of division of whole season's crop. At this stage, 11, 8, 12 and 9 types of division were selected out of 21, for the Assam Valley, Dooars, Cachar and Darjeeling respectively. Because, each part crop of these selected types of division was highly correlated with the corresponding whole season's crop and showed more or less similar results as that of the whole season's crop analysis. Also, these types were common to majority of the experiments within a region.

At the second stage, the results of individual year's analysis of each part crop of the first selected types of division were compared with the results of individual year's analysis of the corresponding whole season's crop. On the basis of the same criteria as that of the first stage selection, at this stage six types of division on pruning and eight on other types of experiments were selected for the Assam Valley, from the first stage selected types of division of whole season's crop. Similarly, for Dooars, Cachar and Darjeeling, six, eight and seven types of division respectively, each on pruning and other types of experiments were selected.

At the third stage, the differences amongst treatments within an experiment and Critical Differences of each part crop of the second stage selected types of division as well as corresponding whole season's crop were found out both for individual year and combined over years of experimentation of all the experiments under study. The results thus obtained for each part crop of each selected type of division of crop were compared with the results of the respective whole season's crop to find out the types of division of crop which showed similar significance of the treatments and similar sign (positive or negative) of the differences amongst treatments. It was found that three types of division of crop each on pruning and other types of experiments in each of the regions, Assam Valley, Dooars and Darjeeling and two each on pruning and other types of experiments in Cachar showed more or less similar results with the respective results of the whole season's crop. These types of division of whole season's crop are shown in Table 2.

Table 2. Types of division of whole season's crop by region and type of experiment.

Type of Experiment	Sl. No.	Region							
		Assam Valley		Dooars		Cachar		Darjeeling	
		Part 1	Part 2	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2
Pruning	1	JL+A	M+J+S+O+ND	JL+A	M+J+S+O+ND	JL+A+S	M+J+O+ND	J+JL	M+A+S+O+ND
	2	J+JL+A	M+S+O+ND	A+S	M+J+JL+O+ND	J+JL+A+S	M+O+ND	JL+A	M+J+S+O+ND
	3	JL+A+S	M+J+O+ND	J+JL+A	M+S+O+ND	—	—	J+JL+A	M+S+O+ND
Others	1	JL+A	M+J+S+O+ND	JL+A	M+J+S+O+ND	A+S	M+J+JL+O+ND	J+JL	M+A+S+O+ND
	2	A+S	M+J+JL+O+ND	A+S	M+J+JL+O+ND	JL+A+S	M+J+O+ND	JL+A	M+J+S+O+ND
	3	JL+A+S	M+J+O+ND	JL+A+S	M+J+O+ND	—	—	J+JL+A	M+S+O+ND

These results indicated that each part of these types of division of whole season, shown in Table 2, could replace the observations on whole season's crop.

Next question was that which one amongst these types of division of crop shown in Table 2 could give best estimate of the whole season's crop in each region for pruning type as well as for other types of experiment. These particular types of division of crop would finally be selected which could give the best estimate of the whole season's crop. This is because the performance of various treatments within an experiment would ultimately be judged on the basis of the whole season's crop. For this purpose, based on theoretical condition, Ratio Method was adopted to estimate the whole seaason's crop from part crop. Accordingly ratio between each part and the corresponding whole season's crop was found out for all the treatments, years and for combined over years of experimentation of all the experiments under study. It was observed that ratios varied amongst types of division of whole season's crop. This was obvious because the proportion of crop varied from types of division to division of whole season's crop. But, within a year and region for each part of a particular type of division of whole season's crop, there was practically no variation in ratios between treatments within an experiment and also between experiments within a particular type of experiments, i.e., pruning or other types. However, from year to year there were variations in ratios. Hence, variance for ratios was calculated for each experiment and an over all estimate of error and corresponding Coefficient of Variation were found out for each selected (shown in Table 2) type of division of whole season's crop and for each type of experiment within a region. Confidence limits for each of these ratios with about one chance in twenty that the true ratio of any year would lie outside these belts were also found out. Considering both parts of the whole season's crop, those types of division were finally selected which showed minimum Coefficient of Variations of the ratios and minimum range of confidence belts. This was because the true ratio of any year between each part and the corresponding whole season's crop of those types of division would be very close to the estimated ratio. Therefore, these types of division were considered to be most efficient to fulfil the objectives outlined. These types of division with the corresponding ratios and their standard errors are shown in Table 3 for all the regions and types of experiments.

These findings clearly suggest that crop from any one of the two periods of the whole season as shown in Table 3 will enable

the experimenter to make treatment comparisons without any appreciable loss of experimental accuracy. This will, therefore, enable the experimenter to conduct more number of experiments with the same number of supervisors, which in turn, not only will minimise the cost of experimentation but also more information will be available within the same period.

Table 3. Most efficient type of division of whole season's crop with corresponding ratios and their standard errors for different types of experiments and regions of North East India.

Region	Assam Valley		Dooars		Cachar		Darjeeling	
Type of Experiment	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2
Pruning	JL+A+S (1.7962± 0.0144)	M+J+O+ND (2.2623± 0.0278)	J+JL+A (2.2227± 0.0573)	M+S+O+ND (1.8179± 0.0357)	JL+A+S (2.0127± 0.1092)	M+J+O+ND (1.9875± 0.1154)	J+JL+A (2.0120± 0.0542)	M+S+O+ND (1.9881± 0.0582)
Others	JL+A+S (1.8389± 0.0166) —	M+J+O+ND (2.1978± (0.0238) —	JL+A+S (1.8925± 0.0345) JL+A (2.9234± 0.0861)	M+J+O+ND (2.1210± 0.0700) M+J+S+O+ND (1.5202± 0.0210)	A+S (3.0630± 0.1246) —	M+J+JL+O+N+D (1.4850± 0.0422) —	J+JL (2.7645± 0.0916) —	M+A+S+O+ND (1.5778± 0.0306) —

Note : Figures within brackets are the ratios and their standard errors.

Crop-Weather Studies

The results obtained from a study on crop and rainfall data for three sub-districts of Dooars were reported in the Annual Scientific Reports for 1973-'74, pp. 69-72 and 1974-'75, pp. 55-57. Similar study on the crop and rainfall data for Binnaguri sub-district of Dooars continued during the year.

Investigation into the available data representing the soil and climatic conditions of Binnaguri Sub-district showed variations within the sub-district and it was found that this sub-district could broadly be divided into northern and southern parts on the basis of rainfall distribution, soil type and level of annual yield. The results obtained so far for one part of the sub-district, i.e., southern part, and these are reported here.

Binnaguri Sub-district (Southern Part)

This part had comparatively lower rainfall and yield than the other part (northern part) and the soil type is also different than the other part.

The critical periods of rainfall for this part of Binnaguri were found to be October and November-December of the previous season, and January-March, April, May, June and July-September of the current season. Rainfall during these periods together contributed about 80 per cent towards the annual yields. The following equation which was derived from the set of data under investigation revealed the nature of relationship between the rainfall during each of these critical periods and the annual yield.

$$Y = 16.9755\,R_1 - 0.7098\,R_1^2 + 13.7682R_2 + 133.3591R_3 - 9.4436R_3^2 + 8.1760R_4 + 22.7622R_5 - 0.2864R_5^2 + 365.0334\,\log_{10}R_6 - 3.6397R_7 + 405.6403 \ldots (1)$$

where, Y = Annual yield of made tea in kg/ha; $R_1, R_2, R_3, R_4, R_5, R_6$ and R_7 denote the rainfall measurements in centimetre during October and November-December of the previous season, and January-March, April, May, June and July-September of the current season respectively.

This equation revealed that rainfall during October of the previous season, January-March and May of the current season were beneficial to the annual crop upto about 12 cm, 7 cm and 40 cm respectively and beyond these limits the annual yield declined. Rainfall during November to December and April, however, were beneficial to the annual crop upto the observed maximum of 8 cm and 29 cm respectively. Whereas rainfall during June showed beneficial effect on the annual crop upto the observed maximum of 127 cm, but the rate of increase in crop gradually declined as the rainfall increased. On the other hand, July to September rainfall was not beneficial to the crop and the crop decreased at a constant rate throughout the observed range.

Further, the study of the rainfall distribution showed that in general in almost all the years rainfall during October, November-December, January-March, April, May and June were much less than the rainfall upto which yield was found to increase during these critical periods and on an average there were deficiencies by at least 1 cm, 6 cm, 2 cm, 15 cm, 11cm and 48 cm respectively (Table 4).

Table 4. Rainfall and quantity of irrigation requirements during critical periods and the estimated gain in annual yield due to irrigation.

Region : Southern Part of Binnaguri sub-district of Dooars.

Critical period	Rainfall in centimetre			Average irrigation requirement with economic return(cm)	Yield of made tea in kg/ha		
	Minimum	Maximum	Average		Actual average	Estimated with optimum irrigation	
						Average	Gain
October (Previous Season)	1	30	11	1			
November to December ,, ,,	0	8	2	6			
January to March (Current Season)	1	10	5	2			
April (,, ,,)	3	29	14	15	1309	1706	397
May (,, ,,)	13	59	29	11			
June (,, ,,)	29	127	79	Uneconomic Drain out excess rain water			
July to September (,, ,,)	145	280	208				
Total irrigation requirement				35			

These results suggested that if these deficiencies were compensated by irrigation, there would be a gain in yield. Irrigation during October, November-December, January-March, April and May would bring substantial increase in annual crop. Whereas the gain in yield due to irrigation in June would be uneconomic, because the increase in crop per unit centimetre of rainfall beyond its average of 79 cm was found to be such that it would unlikely to pay for the cost of irrigation. From Equation 1 it was found that if irrigation was adopted in the southern part of this sub-district to compensate the average water deficiencies of 1 cm, 6 cm, 2 cm, 15 cm and 11 cm during October, November-December, January-March, April and May respectively, and adequate measure was taken to drain out the excess rain water during July-September, average annual yield could be increased from 1306 to 1706 kilograms of made tea per hectare (Table 4). This was equivalent to about 30 per cent (397 kilograms of made tea per hectare) increase over the actual average annual yield of this part of the sub-district (Table 4).

From the economic point of view also, irrigation from October to May to replenish the rainfall deficiencies in this part of the sub-district would be a paying proposition.

Following important points need be stressed in the interpretation and implementation of the above results.

(*i*) *Estimated gain in yield due to irrigation would mainly depend on the period of irrigation, quantity of irrigation in each period and draining out the excess rain water during the critical monsoon period mainly during July to September.*

(*ii*) *The results presented here are conspicuous to the average soil-climatic conditions for the Southern Part of Binnaguri sub-district only. Therefore, if irrigation is proposed for any individual estate, it should be governed by a careful examination of such factors as distribution of rainfall, soil type, depth of soil, etc.*

(*iii*) *Irrigation requirements and draining out of excess rain water as suggested in Table 4 need to be tested by actual field experiments before large scale programme is adopted.*

Survey on Field Management and Environmental Factors Affecting the Yield of Tea.

Darjeeling, West Bengal : The object of this survey is the same as reported earlier in the Annual Scientific Report for 1972-'73, p. 79 for Dooars and Terai survey. Collection of data, checking, coding, preliminary scrutiny, punching and verification of the data were completed during the year. Analysis of the data is in progress. The results obtained so far are summarised below.

(a) **Yield trend :** The yield trend from 1954 to 1973 in all the nine sub-districts of Darjeeling showed wide variations in average annual yield per hectare between years within a sub-district and also between sub-districts. Darjeeling East produced highest crop per hectare (780 kgs of made tea per hectare) during the period 1964 to 1973, while lowest crop per hectare 12 kgs of made tea per hectare) was harvested in Sonada sub-district during the same period.

Further, from the five years moving average of yield per hectare, it was found that in general, there was practi-

cally no increase in yield per hectare from 1954 to 1969 in all the sub-districts. However, from 1969 onwards increasing trend was observed in almost all the sub-districts except Sonada and Darjeeling West. But, in Darjeeling West, there was sharp increase in yield per hectare from 1959 to 1962, and thereafter practically no increasing trend was found.

(b) **Aspect × Nitrogen × Age (Above 60 years old) :** Annual yield of tea increased with the increase in Nitrogen level upto the observed maximum of 120—≤150 in East, South and North aspects, and in other aspects, i.e., West, South-west, South-east and North-east, upto 90 —≤120 kilograms of Nitrogen per hectare. But, the return in yield from unit kilogram of Nitrogen varied from aspect to aspect and also between levels of Nitrogen within an aspect. In East, South and South-east aspects the return was found to be considerable upto 90—≤120 kilograms of Nitrogen per hectare, whereas in other aspects it was negligible beyond 60 —≤90 kilograms per hectare.

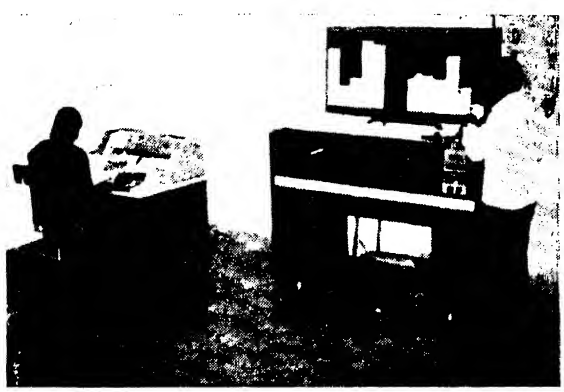
These results, averaged over all elevations, indicate that when the tea bushes are above 60 years old, application of Nitrogen upto 105 kg/ha (mid value of 90 —≤120 kg/ha) in East, South and South-east aspects is likely to be profitable, while in other aspects application beyond 75 kg/ha (mid value of 60—≤90 kg/ha) may not be profitable.

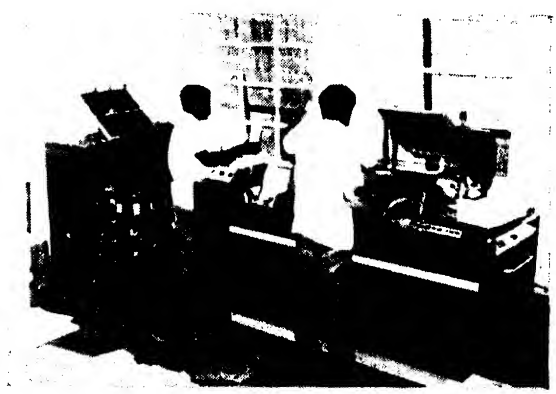
(c) **Elevation × Nitrogen × Age (above 60 years old):** The type of relationship between annual yield of tea per hectare and Nitrogen level showed that at elevation upto 610 m (2000') above sea level, increase in yield was directly proportional to the increase in Nitrogen level upto the observed maximum of 60—≤90 kilograms per hectare. At elevations 610—≤915 m (2000'—≤3000') and above 1525 m (5000') yield increased with increase in Nitrogen level upto the observed maximum of 90—≤120 kilograms of Nitrogen per hectare, and at elevations 915 —≤1220 m (3000'—4000') and 1220 —≤1525 m (4000'—5000') upto the observed maximum of 120—≤150 kilograms per hectare. But, the return in yield from unit kilogram of Nitrogen varied from elevation to elevation. It was also observed that the return varied between levels of Nitrogen within an elevation except at the elevation upto 610 m where the return from unit kilogram of Nitrogen was constant throughout the observed level of Nitrogen, i.e., upto 60 —≤90 kilograms per hectare. On the other hand, at elevations 610 —≤915 m, 915 —≤1220 m and 1220 —≤1525 m, the return was considerable upto 90—≤120 kilograms per hectare and beyond this level substantial reduction in return was observed. Further, at elevation above 1525 m, it was negligible beyond 60—≤90 kilograms of Nitrogen per hectare.

These findings, averaged over all aspects, therefore, suggest that when the tea bushes are above 60 years old, at elevation upto 610 m, application of Nitrogen above 75 kg/ha and upto 105 kg/ha at elevation 610 —≤1525 m is likely to be profitable. Whereas, at elevation above 1525 m, application beyond 75 kg/ha may not be profitable.

Help to other Departments

The Department continued to extend co-operation





Unit Record System in Operation at Tocklai for Data Processing.

and help in solving statistical problems encountered by research workers of practically all the Departments of the Station. Computerised proforma has been prepared for recording all the day to day experimental data of the Station. A number of systems were developed for statistical and mathematical computations on the Unit Record Machines which were installed in July, 1975.

Further, a number of experiments were planned, designed and analysed during the year.

Mr. A. Joyce Mal, student from Assam Agricultural University carried out his dissertation work in the Department in partial fulfilment of the requirement for the M. Sc. (Agriculture) degree.

Agriculture Economics Department

1. Economics of Replantation: The department started a pilot study on 'Economics of Replantation' in April, 1975. The questionnaire was prepared and sent to 93 gardens of South & North Banks of Assam Valley in the 1st week of May, '75. 38 gardens supplied the information and the results of the study were presented in Tocklai Biennial Conference, in Nov. '75. The main observations are :

(a) Yield is the criteria and not only the age to determine the economic life of the tea bush.

(b) Progress of replantation has been slow.

(c) The cost of replantation is about 19,500/- per hectare in the plains of Assam.

(d) The twenty years yield trend shows that the improved cultural practices have helped in higher return from 11.47 qtls. in 1955-59 to 16.91 qtls. in 1970-74 at the initial period of 5 years after replantation. This is most vital for recovering the expenditure and loss of crop.

(e) Break Even Yield (BEY) should be calculated and the section which is giving less than BEY should be uprooted and replanted as it does not contribute to the fixed expenses of the garden.

(f) Pay Back Period should be calculated keeping in view the replantation cost, loss of crop and the interest factor, and the yield from replanted section. The Pay Back Period can come down from 15 years to $8\frac{1}{2}$ years if the interest rate is taken at 6%.

(g) The individual gardens have to take decision keeping in mind (1) long term trends of prices, expenses and yield, (2) sources of finance, (3) impact of overall income and expenses at the gardens.

(h) Provision of funds at lower rate of interest for development purposes like replantation scheme. The provision of cheap money for this purpose by Financial Institutions is urgently needed.

2. **Benefit Evaluation of Tocklai Recommendation—Black Rot Control**

The department completed Cost Benefit Evaluation of Black Rot Control in collaboration with Mycology Department.

The study shows a substantial benefit of Rs. 3708/- per hectare in 5 years without taking into account the interest accrual on the amount which would add another Rs. 340/- at 10% per annum interest.

Black Rot Control is not merely for the benefit of one estate, but for the benefit of adjacent estates and even for the national benefit.

Average Black Rot attack per year is estimated to affect 2% of the total area under tea in the plains. There is, therefore, a potential saving of production 6.1 million kg of tea and net contribution of Rs. 31 millions by an expenditure of approximately 4 million for control of this diseases.

3. **Analysis of Balance Sheet :** The department has received about 150 balance sheets from companies both private ltd., and public ltd. as well as Rupee and Sterling for the period 1973 and 1974. We highly appreciate the help provided to us by the members of TRA in this direction.

The analysis work on balance sheet is progressing and the projection of the impact of fixed and variable costs on the economy of tea would be possible by the end of December, 1976.

4. **Questionnaire on Manuring :** A questionnaire is under preparation for studying the cost benefit studies on the basis of data supplied by the gardens of N. E. India.

5. The department circulated a note to different departments of Tocklai to evaluate at least one of the recommendations of each department during the next one year.

6. The department compiled data regarding Area, Production and Productivity of North East India for

member gardens for 1963 and 1973 and a comparative study table for members and non-members were prepared. The cyclostiled sheets were distributed amongst the Advisory Officers and other officers of Tocklai.

The department should have necessary data on area, production and productivity of the member gardens soon after the year is ended. For this purpose the department has submitted a plan to collect the necessary data from the member gardens with the help of advisory officers. This would be most useful for any exercise to be undertaken by the department.

7. **Motion and Time Study**—The department is starting Motion and Time Study shortly.

Library and Publication Department

LIBRARY

General

Eight new journals were added to the subsription list making the total of 139 journal heads in the Library. In addition to these, the Library receives 101 journals in exchange of Tocklai publications & on free basis. All Foreign journals were subscribed through the INSDOC, New Delhi this year.

Reorganisation

Cataloguing and Classification of books are in progress. A Bibliography on tea is being compiled. Weekly accession list of books, journals etc. were issued to Departments regularly. One Cataloguer was appointed on 12th December '75 but due to her illness she left the service at the end of the year. News paper cuttings on important topics relating to tea and other subjects have continued to be preserved.

Loan Service

Tea Science students of under-graduate and Post-graduate classes of Assam Agricultural University, Scientists of Regional Research Laboratory, Jorhat; Tocklai Scientists, a few Professors of local Colleges, V. P. Trainees of T. R. A. Member estates and State Govt. Officials utilised the Library during the year.

Library Statistics

Total No. of Books--4071
Books added during the year—177
Periodicals and Journals received 1323
New Journals added 8
Pamphlets and Bulletins 680
Photocopy -1
Reprints--105
Publications consulted in the Library 3500
Publications issued to Departments—1660
Books bound during the year--905

PUBLICATIONS

The activities of the Publication Section continued to be increased this year.

The following publications were issued from Tocklai:

1. **Two and A Bud**—Vol. 22, No. 2.
2. **Tocklai News**—Nos. 1 & 2.

Tea Encyclopaedia Serials

3. No. 22/3 Care and Maintenance of Tea Seed Baris (revised).
4. No. 60/2 Drought (revised).
5. No. 194 Vegetative Propagation in Darjeeling (new).

Miscellaneous Reports

6. Annual Scientific Report for 1974-75.
7. Engineering Research & Development Department Quarterly Reports for quarters ending 30th June, 30th September, 31st December, 1975 and 31st March 1976.
8. Contribution of Tocklai Experimental Station to the Tea Industry of North East India.

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES

By

THE ADVISORY DEPARTMENT

South Banks, Assam:

Project	Site	Index	Year of starting
NPK manuring of mature tea	Panitola	AS.108	1973
-do-	Thowra	AS.111	,,
-do-	Rupai	AS.114	,,
-do-	Diffloo	AS.120	,,
Foliar application of zinc	Panitola	AS.109	,,
-do-	Sepon	AS.112	,,
-do-	Daimukhia	AS.115	,,
-do-	Bokakhat	AS.121	,,
Shade in relation to Tea nutrition	Thowra	AS.110	,,
-do-	Bordubi	AS.113	,,
-do-	Methoni	AS.119	,,
Urea Trial	Duklingia	AS.125	,,
Plucking Experiment	Nahortoli	AS. 126	1974
-do-	Lohpohia	AS.123	,,
Infilling Experiment	Halmari	AS.129	,,
-do-	Kaliapani	AS.132	,,
Rejuvenation	Tara	AS.128	,,
-do-	Teloijan	AS.130	,,
-do-	Khoomtai	AS.131	,,
Cultivation Experiment	Deohal	AS.134	1975
North Bank :			
NPK Manuring of mature tea	Naharani	AN.123	1973
-do-	Monabarrie	AN.116	,,
Shade in relation to level of tea nutrition	Dhulapadung	AN.122	,,
-do-	Pertabghur	AN.118	,,
Response to foliar application of zinc	Tezpur & Gogra	AN.124	,,
-do-	Monabarrie	AN.117	,,
Rejuvenation	Kacharigaon	AN.135	1974
-do-	Tezpur & Gogra	AN.136	,,
-do-	Baghmari	AN.137	,,
Infilling	Kacharigaon	AN.140	,,
-do-	Baghmari	AN.141	,,
Nitrogen with and without mulch	Seesa	AN.138	1975
Cachar, Assam :			
Shade in relation to level of tea nutrition	Arcuttipore	C.42	1973
-do-	Pathemara	C.43	,,
Response to foliar application of zinc	Longai	C.41	,,
-do-	Silcoorie	C.40	,,
NPK manuring of mature tea	Silcoorie	C.38	,,
-do-	Longai	C.39	,,
Clonal response to N in different Agro-climatic regions	Coombergram	C.20	1962
Infilling	Longai	C.44	1974
Plucking	Hattikhira	C.45	,,
-do-	Silcoorie	C.46	1975
Rejuvenation	Isabheel	C.47	1974
-do-	Longai	C.48	1974

Dooars & Terai, West Bengal :

Project	Site	Index	Year of Starting
NPK manuring of mature tea	Nimtijhora	D.57	1973
-do-	Bagrakote	D.55	,,
-do-	Sam Sing	D. 56	,,
-do-	Gungaram	TR.7	,,
Nitrogenous Fertilizer	Baradighi	D.33	1967
Clonal response to N. in different Agro-climatic region	Nya Sylee	D.24	1962
Cultivation and weed control	Chuapara	D.42	1970
Shade and nutrition	Dalgoan	D.51	1973
-do-	Gandrapara	D.50	,,
Foliar application of Zinc	Kartick	D.52	,,
-do-	Bhogotpore	D.54	,,
-do-	Baradighi	D.53	,,
Infilling	Kartick	D.41	1969
-do-	Jainti	D.40	,,
-do-	Fagu	D.37	,,
-do-	Sahabad	TR.4	,,
-do-	Mohurgong & Gulma	TR.3	,,
Rejuvenation of old tea	Rydak	D.46	1972
-do-	Dalgaon	D.43	,,
-do-	Mateli	D.44	,,
-do-	Kilcott	D.45	,,
-do-	Kumlai	D.47	,,
-do-	Gungaram	TR.5	,,
Plucking	Birpara	D.58	1974
-do-	Dalsengpara	D.59	,,
-do-	Hansqua	D.60	,,
Clone Vs. Nitrogen trial	Nagrakata	D.48	1973
Potash soil sampling trial	Batabari	D.49	,,
Long term trial	Nagrakata	—	1974
New long term trial	Nagrakata	—	1975
Darjeeling :			
NPK manuring	Chongtong	Dj.34	1973
-do-	Nagri Farm	Dj.35	1973
Nitrogenous Fertilizer	Lingia	Dj.29	1967
Clonal response to N in different Agro-climatic regions	Nagri Farm	Dj.19	1961
P & K with and without weedicide	Chamong, Nagri, Sungma	Dj.31	1970
Pruning	Phoobsering	Dj. 24	1965
	Margaret's Hope	Dj.27	1966
Foliar spraying of zinc sulphate	Sungma	Dj.33	1973
-do-	Arya	Dj.32	1973
Infilling	Bannockburn	Dj.36	1974
-do-	Ging	Dj.37	,,
Rejuvenation	Bannockburn	Dj.38	,,
-do-	Ging	Dj.39	,,

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES By THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

Sl No.	Experiment	Location	Site	Year started
1.	Observation plots of biclonal progenies	North Bank, Assam	Noanipara	1966
2.	-do-	-do-	Cinnatolliah	1974
3.	-do-	South Bank, Assam	Nahorbari	1973
4.	-do-	-do-	Dolowjan	1974

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiments	Location of estate	Site	Index	Year started
1.	Red spider trial	South Bank	Gobindapur T.E.	6	May, 1975
2.	-do-	-do-	Socklatinga T.E.		December, 1975
3.	Scarlet mite trial	-do-	Duflating T.E.		August, 1975
4.	Pink & Scarlet mite trial	-do-	Dhoolie T.E.		March, 1976
5.	Flushworm control trial	-do-	Daimukhia T.E.		May, 1975
6.	Cockchafer trial	Dooars	Baintguri T.E.		September, 1975
7.	-do-	-do-	Meenglass T.E.		-do-
8.	Termite control trial	Cachar	Arcuttipore T.E.		March, 1976
9.	-do-	-do-	Burtoll T.E.		-do-
10.	Effect of weedicides on termite incidence	-do-	Daloo T. E.		-do-
11.	Effect of mulch on termite incidence	-do-	-do-		-do-
12.	Effect of longer pruning cycle on red spider incidence	South Bank	Thowra T. E.		September, 1974
13.	-do-	-do-	Duflating T. E.		-do-
14.	Effect of weedicides on termite incidence	-do-	Moabund T. E.		February, 1976
15.	Incidence of termites on cold & hot patches	Cachar	Borjalinga T. E.		January, 1976
16.	Susceptibility of different clones to termite attack	-do-	Arcuttipore T. E.		-do-
17.	-do-	-do-	Chandighat T. E.		-do
18.	Susceptibility of clones to pink and purple mite attack	Cachar	Burtoll T. E.		January, 1976
19.	Eelworm control trial	Dooars	Nowra Nadi T. E.		December, 1974
20.	-do-	-do-	Lankapara T. E.		-do-

MYCOLOGY DEPARTMENT

Sl. No.	Experiment	Location	Site	Index No	Year Started
1.	To study the effect of application of lower concentration doses of a copper oxychloride formulation in controlling red rust using a hand-operated sprayer.	South Bank, Assam	Gobindapur T. E.	MR 016	1975
2.	Same as above, but with a power sprayer.	-do-	-do-	MR 017	1975
3.	To study the protective action of lower doses/ concentrations of a fungicide in an otherwise heavily red rust affected area, where from the diseased materials were removed in cold weather by heavy pruning. Application of treatments was done with a hand sprayer.	-do-	Bokahola T. E.	MR 018	1975
4.	Same as above but with a power sprayer.	-do-	-do-	MR 019	1975
5.	Screening of different fungicides against red rust.	South Bank, Assam	Gobindapur T. E.	MR 020	1975
6.	Testing of a new fungicide against Thorny stem blight.	Darjeeling	Happy Valley T. E.	MC 006	1975
7.	Screening of fungicides against Black rot.	South Bank, Assam	Gobindapur T. E.	MB 012	1975
8.	Study of the effect of application of different-concentration of a copper oxychloride formulation in controlling Black rot with hand sprayer.	-do-	Diffloo T. E.	MB 013	1974
9.	Screening of fungicides against Blister blight .	Darjeeling	Phoobsering T. E.	MF 004	1975
10.	Chemical control of Primary root disease	South Bank, Assam	Nahorkatia T. E.	MP 002	1973
11.	-do-	-do-	Borhat T. E.	MP 003	1974
12.	-do-	North Bank,	Tarajuli T. E.	MP 004	1975
13.	-do-	-do-	Thakurbari	MP 006	1975
14.	-do-	Darjeeling	Balasum T. E.	MP 005	1974

STATISTICS DEPARTMENT

Sl. No.	Department	Project	Site	Index No.	Year started
1.	Statistics	Uniformity trial	Nagri Farm (Darjeeling, West Bengal)		1964

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl. No.	Experiments	Location of estate	Site	Index No.	Year started
1.	Trial of continuous Tea Roller	South Bank	Borbam T. E.		1975
2.	Trial of Withered Leaf Preconditioner	-do-	-do-		1975

Appendix-C

PUBLISHED PAPERS & PAPERS IN THE PRESS

Banerjee, B. 1976. Development of the red crevice mite *Brevipalpus phoenicis* (Geijskes) on coffee and tea. *J. Appl. Ent.* (Z. *angew. Ent*) 80 : 242—346.

(Abs. at 23±3°C with 80 ± 5% RH and LD 12 :12, the life cycle of the red crevice mite *Brevipalpus phoenicis* (Geijskes) is completed in 36 days on coffee leaves and 25 days on tea leaves. Early larval feeding sets in the course of development specific to the host plants. A change in diet at any post larval stage is ineffective in altering the developmental rate already set in during larval feeding. It is stipulated that growth promoting or retarding substance(s) in host plants act differentially on the larvae to influence their subsequent developmental rates.)

Banerjee, B. 1976. Variance to mean ratio and spatial distribution of animals. *Experientia*, 92: 993—995.

(Abs. Biological and statistical aspects of the application of the variance to mean ratio to spatial distribution of animals are discussed. It is shown that the parameter *b* in Taylor's Power Law $S^2 = a\ m^b$ shows intra-specific variation depending on the distribution of the constituent units of the population. *a* and *b* are only parameters of a very empirical way of describing the relation between variance and mean, which itself is an indicator for spatial distribution. Hence, *a* and *b* depend on the distribution behaviour of the animals, and not vice versa.)

Banerjee, B. 1976. Pesticides requirement for tea plantations. In *Rationalisation of the pesticide industry and strategies for proper deployment of pesticides.*

(Abs. Qualitative and quantitative aspects of the trend in pesticides requirements of North East Indian tea industry is discussed. An estimated Rs. 20 crore worth of pesticide is the annual turn over.)

Banerjee, B. and Basu, S. D., 1976. The minimal time required for nematode extraction by Oostenbrink's elutriator. *Curr. Sci.*, 45 : 271.

(Abs. A modification of the Oostenbrink's Elutriator has greatly increased the efficiency of the extraction of nematodes from the soil. About 86% of the extractable population is obtained within 3 hours, compared to 12 hours earlier, after processing. There was only a 4% variability in the extraction efficiency.)

Banerjee, B. and Sarma, N. N., 1976. Bionomics of *Sternocera aurosignata* Thompson (Buprestidae : Coleoptera) a pest of shade trees in tea plantations of North-East India. *Ind. J. Ent.*, 37 (4) : (in press).

Banerjee, B., Das, S. C. & Mukherjee, S. New records of coccoids from shade trees and ancillary crops of tea in North-East India. *Ind. J. Ent.* (in press).

Banerjee, B. An exercise in mathematical demography of *Odontotermes redemanni* (Wasmann). *Proc. Nat. Acad. Sci. Lon.* (in press).

Jain, N. K. & Agrawal, M. C. 1974. Studies on Comparative Efficiency of Different Nitrogenous Fertilizers for Soil and Foliar Application on Dwarf Wheat Sonora-64. Indian J. Agric. Res. 8(3), Sept.'74, 153 -156.

(Abs. Four nitrogenous fertilizers viz. urea, ammonium sulphate, ammonium chloride and calcium ammonium nitrate were compared for soil and foliar application in wheat Sonora-64 at the Student's Instructional Farm of the U. P. Institute of Agricultural Sciences, Kanpur for two consecutive crop seasons of 1967-68 and 1968-69. Ammonium sulphate as soil application and urea as foliar spray were found suitable fertilizers for maximising the grain and straw yields of wheat.)

Satyanarayana, G. & Barua, G. C. S. 1975. Trends in disease control with special reference to tea in N. E. India. Pesticides Annual, 106—114.

(Abs. Trends in the control of important parasitic and non-parasitic diseases of tea have been dealt with. Recognition of primary and or secondary nature of the diseases and the identification of the influence of different field management methods on the degree of disease development have enabled standardization on disease control measures in two phases. (1) Cold weather treatments are aimed at correction of disease inducing factors in the field proper managements of shade, green crops, drainage, pruning cycles etc. are looked into. (2) Treatments during the actively growing season is characterized by spraying chemotherapeutants following disease symptom build up.

Satyanarayana, G. & Barua, G. C. S. 1976. Red rust an important disease of tea. Abstract in Proceedings of Indian Sc. Cong. Assocn. 63rd Session held at Waltair Part III, 141.

(Abs. 'Red rust' of tea is caused by an alga *Cephaleuros parasiticus* Karst. and not by any fungus belonging to the common rusts known to the pathologists. It is a serious disease of young tea, causing branch die-back and hindering frame formation. In this paper the history of its occurrence in North East India together with its present depredations, life history, factors influencing severity of its attack and control measures are dealt with. A paragraph on the nomenclature of the alga, another on alternate hosts from amongst shade tree and green crop plants used in tea cultivation, are also included.

Appendix-D

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1975

Table 1. Tocklai (Mid Assam)

Latitude : 26°47′ N Longitude : 94°12′ E Altitude : 96.5m a.m.s.l.

Months 1975	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	22.4	9.8	16.1	24.7	6.2	12.3	4	6.9	17.9	17.7	19.2	39.3	61.5
	(22.3)	(9.4)	(15.8)			(21.8)	(5)	(5.8)	(18.6)	(18.2)	(19.0)		
February	24.2	13.3	18.7	30.0	10.5	27.3	8	7.1	20.5	20.0	20.5	51.5	86.0
	(24.0)	(11.9)	(18.0)			(32.0)	(7)	(6.2)	(20.4)	(19.8)	(20.2)		
March	29.3	15.9	22.6	33.6	13.0	8.3	3	8.2	24.9	23.8	23.7	97.6	139.5
	(27.5)	(15.5)	(21.5)			(80.8)	(11)	(6.7)	(24.0)	(23.0)	(23.0)		
April	29.2	20.1	24.6	36.3	16.0	199.5	15	5.7	26.7	25.9	25.8	104.8	143.0
	(28.7)	(11.0)	(23.8)			(192.6)	(16)	(5.9)	(26.8)	(25.8)	(25.6)		
May	29.7	22.2	26.0	33.9	19.5	139.9	18	5.1	28.8	28.2	28.1	97.2	151.3
	(29.9)	(21.8)	(25.8)			(282.5)	(20)	(5.0)	(28.7)	(27.8)	(27.6)		
June	32.5	25.0	28.8	35.3	21.2	321.9	24	6.2	31.6	30.8	30.5	101.7	173.0
	(31.5)	(24.0)	(27.8)			(330.7)	(23)	(4.5)	(30.6)	(29.7)	(29.5)		
July	31.6	25.0	28.3	34.2	23.8	353.5	29	4.5	31.2	30.8	30.8	103.2	155.5
	(32.2)	(24.6)	(28.4)			(381.4)	(25)	(4.7)	(31.4)	(30.6)	(30.5)		
August	32.3	25.5	28.9	36.5	23.5	379.3	17	6.0	31.4	30.8	31.0	98.9	167.1
	(32.0)	(24.6)	(28.3)			(342.6)	(23)	(5.0)	(31.4)	(30.6)	(30.6)		
September	30.9	24.4	27.6	33.7	22.7	358.5	23	4.8	30.2	29.8	30.2	73.8	128.7
	(31.2)	(23.9)	(27.6)			(252.3)	(19)	(5.0)	(30.8)	(30.2)	(30.2)		
October	29.9	22.8	26.4	33.2	18.7	210.4	15	5.5	28.8	28.5	29.0	59.9	115.9
	(29.3)	(21.0)	(25.2)			(116.7)	(12)	(5.6)	(28.4)	(28.0)	(28.4)		
November	26.5	16.4	21.4	29.6	11.2	29.2	4	6.0	23.9	24.0	24.6	39.5	82.0
	(26.3)	(15.2)	(20.8)			(27.4)	(4)	(6.1)	(24.0)	(23.6)	(24.6)		
December	22.9	10.4	16.6	25.4	7.4	11.0	4	6.8	18.6	19.8	20.2	33.5	61.2
	(23.4)	(10.6)	(17.0)			(10.9)	(3)	(6.0)	(19.8)	(19.6)	(20.6)		

PER CENT RELATIVE HUMIDITY

Table 1(a). Tocklai

Hours of observations IST	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0613	94	92	85	87	91	92	91	92	95	95	95	94
	(96)	(94)	(92)	(91)	(92)	(92)	(93)	(94)	(95)	(96)	(97)	(97)
1313	55	54	39	59	69	71	75	74	74	73	63	57
	(58)	(54)	(54)	(63)	(71)	(75)	(75)	(75)	(74)	(72)	(64)	(60)

Notes : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimation of evaporation from an open water surface

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1975

Table : 2. Silcoorie (Cahar)

Latitude : 24°50′ N Longitude : 92°48′ E Altitude : 39.5m a.m.s.l.

Months 1975	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	25.8 (25.9)	10.3 (10.9)	18.0 (18.4)	28.5	6.4	— (19.6)	— (2)	8.1 (8.0)	20.5 (21.3)	?	?	63.2	78.6
February	27.9 (27.6)	13.5 (12.8)	20.7 (20.2)	31.5	8.5	50.2 (51.9)	5 (4)	8.0 (8.2)	22.6 (23.2)	?	?	67.9	101.7
March	31.7 (30.7)	16.4 (16.4)	24.0 (23.6)	35.5	11.1	32.6 (105.3)	3 (7)	9.3 (8.0)	26.7 (26.9)	?	?	110.4	163.8
April	32.5 (31.8)	20.4 (20.4)	26.4 (26.1)	35.8	14.6	274.1 (251.8)	17 (14)	8.4 (7.6)	29.0 (29.4)	?	?	114.4	177.5
May	31.8 (31.8)	22.5 (22.7)	27.2 (27.2)	35.6	19.1	402.5 (381.4)	20 (19)	6.5 (6.5)	29.8 (30.6)	?	?	119.6	174.1
June	33.0 (31.5)	25.0 (24.4)	29.0 (28.0)	36.5	22.2	328.8 (605.3)	18 (25)	6.0 (4.1)	31.6 (30.6)	?	?	99.5	169.8
July	31.0 (32.1)	24.4 (24.9)	27.7 (28.5)	34.7	22.1	515.4 (525.8)	29 (27)	3.4 (4.4)	30.4 (31.4)	?	?	77.1	137.1
August	32.8 (32.2)	25.0 (24.9)	28.9 (28.6)	36.8	23.7	226.3 (439.8)	19 (25)	5.7 (4.8)	31.5 (31.4)	?	?	95.6	164.1
September	31.7 (32.3)	24.3 (24.4)	28.0 (28.4)	34.6	23.2	268.6 (339.8)	19 (18)	4.8 (5.7)	30.6 (26.2)	?	?	82.8	144.5
October	31.9 (31.3)	23.4 (22.5)	27.6 (26.9)	34.1	22.1	127.6 (215.6)	14 (11)	6.9 (6.6)	30.2 (29.6)	?	?	79.7	136.1
November	28.1 (29.3)	17.4 (17.3)	22.8 (23.3)	32.1	13.2	135.0 (301.2)	7 (3)	6.5 (7.8)	25.3 (26.0)	?	?	58.4	98.3
December	26.1 (26.9)	11.0 (12.5)	18.6 (19.7)	28.9	8.7	— (10.6)	0 (1)	8.3 (8.0)	21.0 (22.6)	?	?	52.7	77.9

PER CENT RELATIVE HUMIDITY

Table 2(a). Silcoorie

Hours of observations IST	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	99 (98)	97 (97)	92 (94)	91 (91)	92 (91)	94 (95)	96 (96)	95 (96)	97 (95)	97 (96)	98 (97)	99 (98)
1319	48 (46)	44 (43)	42 (43)	55 (57)	68 (67)	70 (76)	80 (75)	71 (74)	73 (71)	70 (68)	62 (56)	48 (49)

Notes :
(i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimation of evaporation from an open water surface
(iv) ? indicates data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1975

Table 3. Nagrakata (Dooars)

Latitude : 26°54′ N Longitude : 88°55′ E Altitude : 228.6m a.m.s.l.

Months 1975	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	24.0	10.0	17.0	27.3	7.8	—	—	7.9	18.2	18.5	19.4	78.3	72.9
	(23.6)	(10.5)	(17.0)			(13.3)	(2)	(7.6)	(18.2)	(18.4)	(19.6)		
February	25.1	12.9	19.0	30.2	8.6	24.4	6	6.2	20.4	20.6	20.1	84.9	84.9
	(25.5)	(12.8)	(19.2)			(19.7)	(3)	(7.5)	(20.2)	(20.0)	(20.7)		
March	30.8	16.2	23.5	34.8	12.7	8.2	1	7.9	25.8	25.7	25.2	164.0	150.0
	(29.3)	(16.4)	(22.8)			(41.6)	(5)	(7.6)	(24.0)	(23.6)	(23.8)		
April	32.2	21.1	26.6	37.0	16.7	49.6	8	6.1	29.0	28.8	28.1	166.1	159.1
	(31.0)	(20.0)	(25.5)			(145.6)	(11)	(7.1)	(26.9)	(26.3)	(26.4)		
May	31.2	22.0	26.6	34.7	18.9	165.9	17	6.0	29.4	28.9	29.3	167.4	167.7
	(30.8)	(21.7)	(26.2)			(357.3)	(20)	(6.6)	(28.3)	(27.6)	(27.8)		
June	31.4	23.6	27.5	35.2	21.6	931.5	27	5.0	28.9	28.6	28.8	135.0	152.6
	(30.3)	(23.3)	(26.8)			(874.8)	(26)	(3.8)	(28.5)	(28.0)	(28.4)		
July	29.9	23.6	26.8	32.5	22.0	1,260.8	30	2.3	28.0	27.6	?	60.7	118.1
	(30.4)	(23.9)	(27.2)			(1,077.2)	(27)	(3.4)	(28.9)	(28.8)	(28.6)		
August	31.7	24.0	27.8	35.7	22.5	291.2	23	5.0	29.1	28.1	28.8	109.7	150.7
	(30.6)	(23.8)	(27.2)			(781.1)	(27)	(4.0)	(29.0)	(28.8)	(28.8)		
September	30.2	23.2	26.7	33.7	21.7	596.5	23	3.9	28.1	27.9	28.2	90.9	121.6
	(30.6)	(22.9)	(26.1)			(550.1)	(22)	(5.1)	(28.8)	(28.7)	(28.7)		
October	30.2	21.6	25.9	32.2	19.0	204.7	11	7.1	27.7	27.8	28.1	94.4	130.1
	(29.8)	(19.6)	(24.7)			(226.4)	(10)	(7.7)	(26.8)	(27.2)	(27.2)		
November	27.3	15.3	21.3	30.0	12.3	—	0	9.0	23.0	23.6	24.6	80.8	98.9
	(27.4)	(14.7)	(21.0)			(12.4)	(3)	(8.7)	(22.6)	(23.0)	(24.0)		
December	25.0	11.7	18.4	26.0	9.0	—	0	7.9	20.4	20.3	21.4	68.1	70.8
	(24.8)	(11.5)	(18.2)			(3.7)	(1)	(8.4)	(20.6)	(19.8)	(21.0)		

PER CENT RELATIVE HUMIDITY

Table 3(a). Nagrakata

Hours of Observations IST	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
0634	82	85	66	72	88	94	97	93	96	93	86	86
	(85)	(81)	(74)	(77)	(87)	(95)	(96)	(95)	(95)	(89)	(85)	(96)
1334	43	47	32	52	66	78	86	79	78	69	54	53
	(52)	(48)	(45)	(54)	(69)	(82)	(83)	(82)	(78)	(67)	(56)	(53)

Notes : (i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimation of evaporation from an open water surface
(iv) ? indicates data not available

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1975

Table 4. Nagri Farm (Darjeeling)

Latitude : 26°55′ N Longitude : 88°12′ E Altitude : 1158.2m a.m.s.l.

Months 1975	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	15.6	8.2	11.9	19.7	5.7	9.4	2	6.4	12.2	10.2	13.8	55.1	62.7
	(15.1)	(7.8)	(11.4)			(19.3)	(3)	(6.1)	(13.2)	(12.4)	(14.1)		
February	16.6	9.5	13.0	23.8	6.0	12.3	6	5.3	14.8	12.2	14.3	52.6	68.8
	(16.7)	(9.5)	(13.1)			(17.4)	(3)	(5.9)	(14.8)	(12.8)	(14.5)		
March	24.0	14.0	19.0	28.0	9.6	4.1	1	7.9	20.8	17.3	18.7	139.6	142.6
	(21.2)	(13.1)	(17.2)			(52.5)	(5)	(6.7)	(19.0)	(17.1)	(17.6)		
April	25.4	17.0	21.2	30.8	14.0	90.4	22	6.1	23.6	20.8	21.8	136.4	146.0
	(23.5)	(15.8)	(19.6)			(101.3)	(10)	(5.6)	(21.8)	(20.0)	(20.3)		
May	24.8	16.0	20.4	26.8	15.0	175.4	19	5.1	23.8	22.0	22.6	93.0	136.0
	(23.9)	(17.2)	(20.6)			(197.4)	(19)	(5.2)	(23.5)	(21.8)	(22.0)		
June	24.9	18.8	21.8	27.8	15.8	690.0	27	3.2	24.5	23.0	23.2	63.0	116.6
	(24.1)	(18.8)	(21.4)			(424.6)	(25)	(3.0)	(24.5)	(23.0)	(23.2)		
July	24.5	18.4	21.4	27.9	17.0	747.3	31	1.5	24.1	21.7	23.2	49.6	102.9
	(24.3)	(19.4)	(21.8)			(672.0)	(27)	(2.4)	(24.8)	(23.4)	(23.8)		
August	26.1	19.1	22.6	30.8	17.7	178.2	21	3.9	25.6	23.0	24.2	65.8	123.8
	(24.8)	(19.1)	(22.0)			(476.4)	(25)	(3.2)	(25.4)	(23.8)	(24.2)		
September	24.1	17.7	20.9	27.9	16.4	523.4	27	1.7	23.4	20.9	23.0	48.7	84.6
	(24.4)	(18.2)	(21.3)			(316.2)	(20)	(4.0)	(24.4)	(23.0)	(23.7)		
October	24.8	17.0	20.9	27.8	14.2	84.3	11	5.9	23.6	21.2	22.8	66.5	102.9
	(23.3)	(15.7)	(19.5)			(143.7)	(8)	(6.6)	(22.1)	(20.8)	(21.8)		
November	22.1	11.4	16.8	23.9	9.0	—	0	6.8	18.6	16.7	19.0	57.4	76.2
	(20.5)	(11.9)	(16.2)			(12.3)	(2)	(7.4)	(18.2)	(17.0)	(18.8)		
December	16.9	8.5	12.7	22.8	6.5	0.3	1	5.5	14.6	12.6	15.4	42.7	54.6
	(17.6)	(9.2)	(13.4)			(3.6)	(1)	(6.9)	(14.7)	(13.8)	(15.3)		

PER CENT RELATIVE HUMIDITY

Table 4(a). Nagri Farm

Hours of observations IST	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637	62	74	51	63	80	91	95	89	91	85	70	71
	(72)	(69)	(64)	(68)	(81)	(92)	(94)	(93)	(89)	(77)	(67)	(68)
1337	59	70	39	57	79	87	90	82	90	82	67	70
	(73)	(65)	(60)	(67)	(82)	(89)	(89)	(87)	(86)	(79)	(70)	(70)

Notes : (i) Data in brackets show previous average
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means Penman estimation of evaporation from an open water surface.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1975

Table : 5. Thakurbari (North Bank)

Latitude : 26°48'35" N Longitude : 92°42'35" E Altitude : 92.45m a.m.s.l.

Months 1975	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (under grass)			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.3 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	24.1 (23.4)	8.2 (9.0)	16.2 (16.2)	26.3	5.0	16.4 (36.2)	3 (6)	8.0 (7.6)	?	?	?	53.9	66.7
February	25.8 (26.2)	11.6 (11.4)	18.7 (18.8)	31.8	8.0	13.2 (0.4)	4 (2)	8.0 (7.2)	?	?	?	67.8	86.1
March	31.5 (29.4)	15.0 (15.1)	23.2 (22.8)	35.6	11.6	4.8 (45.3)	1 (5)	8.2 (6.9)	?	?	?	127.4	145.8
April	30.9 (30.3)	19.2 (20.2)	25.0 (25.2)	36.1	16.0	254.7 (160.7)	14 (17)	6.0 (6.3)	?	?	?	133.2	152.5
May	31.1 (31.0)	21.6 (22.1)	26.8 (26.6)	35.1	19.0	174.5 (246.0)	15 (17)	6.9 (5.6)	?	?	?	119.7	169.9
June	32.8 (31.4)	24.2 (24.4)	28.5 (27.9)	35.7	20.7	203.8 (536.4)	17 (24)	5.9 (3.6)	?	?	?	116.4	165.5
July	31.4 (32.3)	24.5 (25.0)	28.0 (28.6)	34.2	22.8	596.5 (512.6)	27 (20)	4.2 (4.6)	?	?	?	101.1	147.1
August	33.0 (32.4)	24.6 (25.0)	28.8 (28.7)	37.5	22.5	366.5 (292.0)	14 (18)	6.0 (5.2)	?	?	?	103.5	166.0
September	31.5 (31.2)	23.4 (23.4)	27.4 (27.3)	35.4	21.8	289.6 (377.5)	18 (20)	4.9 (5.1)	?	?	?	69.7	130.9
October	30.8 (30.8)	21.6 (21.6)	26.2 (26.2)	33.9	17.0	323.0 (164.6)	15 (10)	6.1 (6.5)	?	?	?	75.0	122.4
November	27.9 (28.5)	14.1 (15.1)	21.0 (21.8)	31.3	9.0	1.3 (15.3)	1 (2)	8.4 (8.1)	?	?	?	59.1	90.7
December	24.7 (24.4)	8.5 (9.6)	16.6 (17.0)	26.8	5.5	17.6 (21.2)	3 (4)	8.5 (7.9)	?	?	?	46.1	62.9

PER CENT RELATIVE HUMIDITY

Table 5(a). Thakurbari

Hours of observations IST	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	90 (96)	90 (92)	82 (86)	83 (88)	89 (91)	91 (94)	94 (94)	93 (94)	94 (93)	94 (93)	92 (93)	94 (94)
1319	48 (61)	48 (52)	42 (52)	59 (66)	66 (72)	71 (78)	79 (76)	73 (76)	75 (77)	73 (72)	60 (60)	53 (58)

Notes :
(i) Data in brackets show previous averages
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) Penman in mm means penman estimation of evaporation from an open water surface
(iv) ? indicates data not available